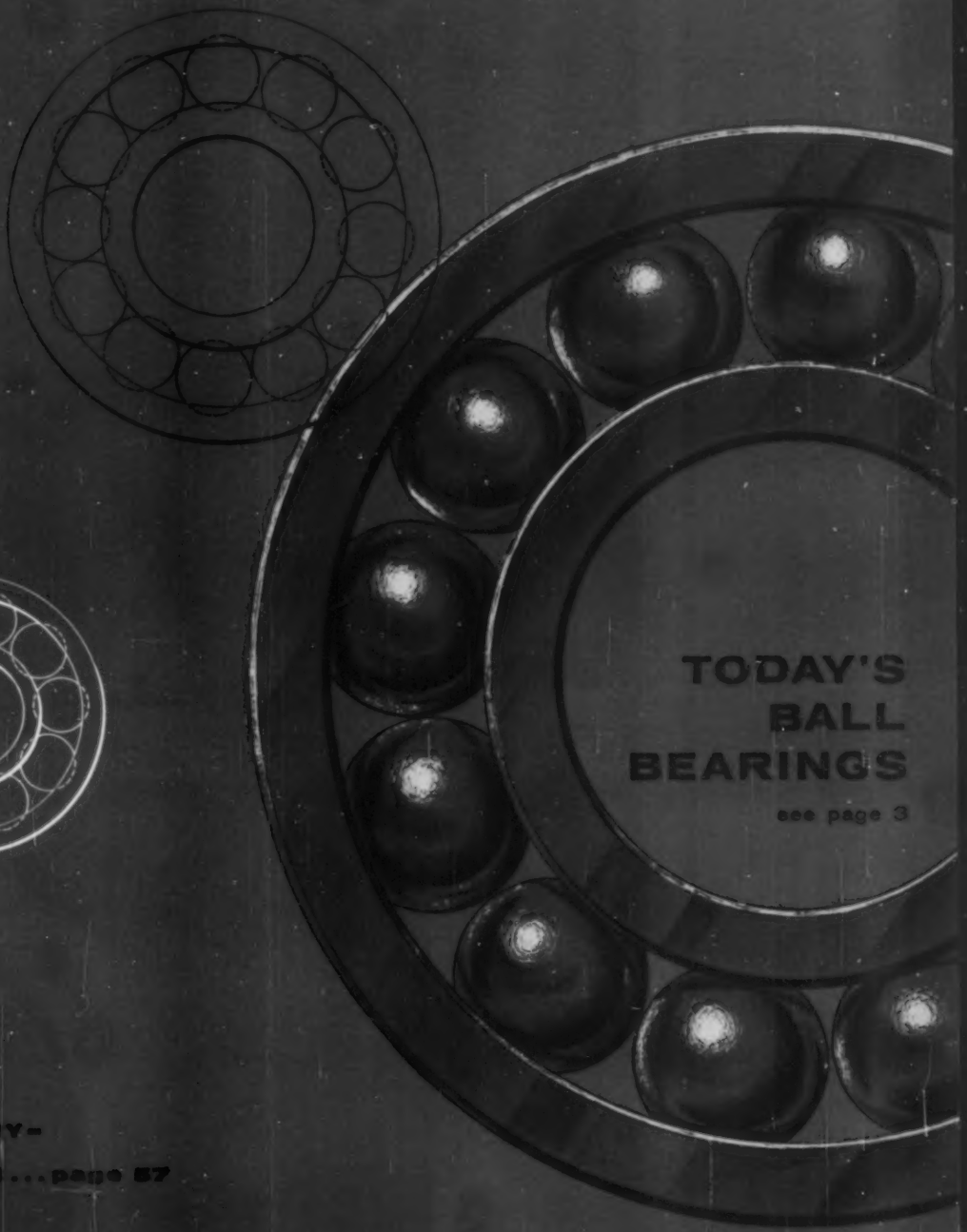
PRICE 50 CENTS

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · DECEMBER 12, 1960



TODAY'S BALL BEARINGS

see page 3

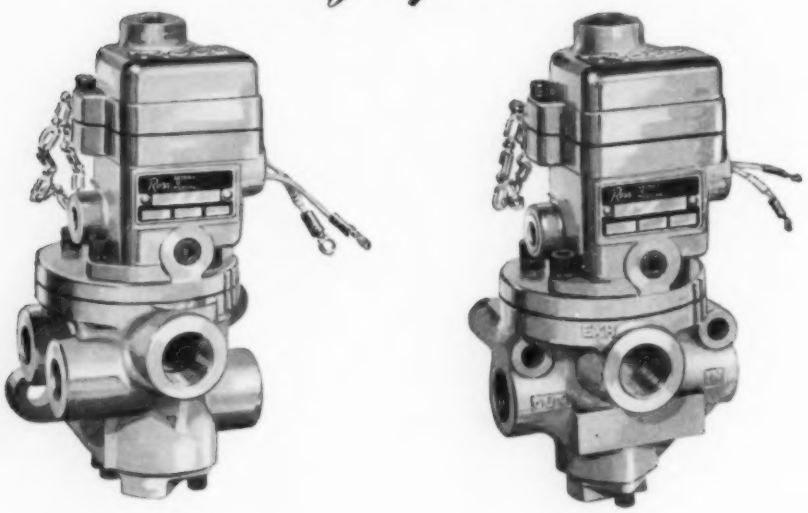
SAMPLING THEORY—
AN EXERCISE
IN PROBABILITIES ... page 57

CREATIVITY—
A NEW APPRAISAL ... page 76

HOW TO FIND
TRAPEZOIDAL-SPRING
DEFLECTION ... page 93

Ross

Proudly presents



THE NEW "HEADLINE" SERIES

A complete new series of inline valves, sizes one-quarter inch through one and one-half inch, straightway, 3-way and 4-way. These valves, size for size, will operate faster, longer, and provide greater capacity than any other valves we have been able to find.

When the price, quality and performance and Ross reputation are taken together in evaluating this series, it represents probably the best valve value available today. Before you specify any valve after today, you owe it to yourself to look into the "headline" series. Write for full information.

Ross OPERATING VALVE COMPANY

114 EAST GOLDEN GATE AVE. • DETROIT 3, MICHIGAN

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

December 12, 1960 Vol. 31, No. 51

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 6
WHAT'S NEW IN RESEARCH 9
THE ENGINEERING WEEK 15
APPEARANCE DESIGN 24
READER TO EDITOR 28
MEETINGS 29
WHY NOT R&D 32
HORIZONS 55
PRODUCT DESIGNS 60
SIGNIFICANT COMPONENTS 87
REPRINTS 102
DESIGN LITERATURE 106
ADVERTISERS INDEX 119
READER SERVICE CARDS 121

SAMPLING THEORY—EXERCISE IN PROBABILITIES . . . R M Koff
The equation—and a graphical plot to speed computation 57

TODAY'S BALL BEARINGS—YOUR CHOICE . . . N P Chironis
Special report brings you up-to-date, compares the types 63

CREATIVITY—A NEW APPRAISAL . . . E J Tangerman
Latest ideas on what industry wants, how to spot inventive talent 79

FINDING DEFLECTION OF TRAPEZOIDAL SPRINGS . . . J Palm
Easier way is offered by this German author 83

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:

Nickel-free brasses and steels developed in India 6
New magnetic materials promise high strength at low cost 8
Another space problem—sublimation in thin air 9
Superalloy gives better, cheaper brake-return spring 15

MECHANICAL:

Pump-motor system recovers "lost energy" 6
Grooves damp vibration of bearings 6
Simplified plug has dual locking action 8
Soviet engineer reports on servo clutch design 9
Oil-impregnated sintered-steel core lubes flexible coupling 87

ELECTRICAL:

Non-contact heads sense shaft rotation magnetically 87
Introducing the tunneltron—rival to tunnel diode 17

PRODUCT DESIGNS:

Fills tank precisely—without need for floats 60
Rail guides car for tunnel police 61
Flexible gears provide high ratios 62

GENERAL:

Thermonuclear progress—a look at 30 million degrees 9
Compact truck bids for slice of market 17
Master Design Awards announced for achievement in product development 21

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

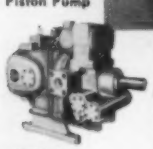
DENISON HydrOILics

DENISON hydraulic equipment powers 21 hatch covers and anchor windlasses aboard new "Export Agent"

CONTROL

60 Series Fluid Motor

500 Series Constant Volume Axial Piston Pump



60 Series Variable Volume Axial Piston Pump

"EXPORT AGENT"... new 10,210 ton cargo ship built by the National Steel and Shipbuilding Co., San Diego... incorporates precise, reliable Denison hydraulic equipment to power hatch covers and anchor windlasses.

FIRST of the new replacement fleet for *American Export Lines*—the "Export Agent" is designed to carry over 643,000 cubic feet of general cargo. Largest and fastest cargo vessel now operated by *A.E.L.*—this ship is equipped with many new cargo handling devices... including 21 hydraulic hatch covers, powered by Denison hydraulic equipment.

The hatch cover system—built by Greer Marine, Inc., Catasauqua, Pa.—incorporates 500 Series Denison constant volume pumps. Operation is fast, simple and safe. *Result: Important time savings* in cargo handling plus minimum cargo damage in bad weather.

In addition, the anchor windlasses—supplied by The Hyde Windlass Co., Bath, Maine—are powered by Denison 60 Series handwheel-controlled variable volume axial piston pumps and fluid motors. Maximum fluid motor speed is 1150 rpm. Output of the pumps is 120 gpm at 1200 rpm. *Result: Precise, accurate control and reliability* for the anchor windlass system.

Denison hydraulic equipment is engineered to deliver low-cost fluid power for every marine need—steering systems... cargo handling... winch and windlass drives. Your nearby Denison Hydraulic Specialist can help you save time and money on *your* next marine hydraulics problem. Write for details.

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1194 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

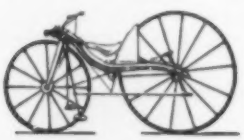
INTERESTING TO NOTE

On our cover—the ball bearing in various stages of design, from blueprint to steel. There now are dozens of variations in the basic design theme. You'll find a selection guide on page 63.

The principle of the bearing can be traced back to pre-Biblical vehicles. These were simply the journal type that had to be greased. It took many centuries before rolling elements, instead of grease, were put into the bearing cup or sleeve.

According to the *McGraw-Hill Encyclopedia of Science and Technology*, "the first major application of the rolling element bearing was to the bicycle." This is curious, since the bicycle is a rather new development.

It was in 1816 that Joseph Niepce, a pioneer of photography, attached two wheels to a crossbar so that, when he straddled the bar he could get up speed by running. Then he sat on the bar and coasted. The idea caught on quickly and in time the contraption became a toy for the wealthy—they called it a "dandy-horse." A true bicycle was developed in 1839 when a Scotsman, Kirkpatrick MacMillan, took a dandy-horse and added pedals, driving rods, a seat and handlebars. He drove his bicycle for many years over the rough roads of Scotland, once being prosecuted and fined for "furious driving." There are no available records describing the types of bearings used on MacMillan's bicycle or Niepce's dandy-horse but they were probably simple tallow-lubricated friction bearings.



The first bicycle

Proving Polish Doesn't Pay

In days of old, two of the most prized industrial secrets involved the manufacture of plate glass and the forging of swords. The secrets of glass plate were kept by a select few on the island of Murano near Venice; swords could be made by any blacksmith, but only a few knew how to make a blade strong enough to withstand the trial of battle. It has been said that one of the reasons the Romans defeated the Celts was armament—the Celtic swords were poorly tempered and had to be straightened after each blow.

In early times, each blacksmith had his own trade secrets which he either developed himself or learned from his father. Blacksmiths were not steel experts; they learned their trade by trial and error. So some of their methods may seem strange to a metallurgist. For example, one story claims that the famous Damascus blades used by special warriors were tempered by plunging the hot steel into the body of a slave.

In time it was generally accepted that because the steel blades made in Damascus and Toledo were shiny, a highly

PRODUCT ENGINEERING

ELMER J TANGERMAN *editor*

STANLEY J ALLING *publisher*

ROBERT W CARSON *managing editor*
RICHARD M KOFF *assistant managing editor*

ROBERT E ABBOTT *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD PARK *associate editor*
ROBERT PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*
FREDERICK MARICH *assistant editor*
JOHN PRICE *assistant editor*

FRANCIS E HALL *assistant editor*
BRUCE H FRISCH *assistant editor*
ANITA CAMERIK *assistant editor*

FELIX GIORDANO *Detroit*
SETH PAYNE *Washington*
WILLIAM WALLACE *Los Angeles*

RICHARD E ROOMAN *art director*
E K LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DOUGLAS GREENWALD *manager, economics services*

C C KANE *reader service manager*

McGraw-Hill News Bureaus

JOHN WILHELM *director*
MARGARET RALSTON *assistant*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*
STEWART W RAMSEY *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*
JOHN TUNSTALL *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
CURT AGREN *Stockholm*
ERNEST CONINE *Moscow*
JIM MORRISON *Bonn*
FRED BAER *Vienna*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

A McGRAW-HILL PUBLICATION

ABP

December 12, 1960
Vol. 31, No. 51

ABC

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N. Y.
Telephone: LOngacre 4-3000
Teletype: TWX NY 1-1636
Cable Address: MCGRAW-HILL, NY

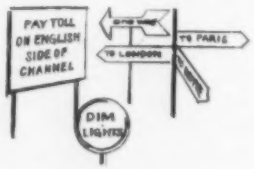
PRODUCT ENGINEERING is published weekly by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. Qualified subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Printed in Albany, NY; second-class postage paid at Albany, NY. Title ® registered at U.S. Patent Office. © Copyright 1960 by McGraw-Hill Publishing Company, Inc. All rights reserved, including the right to reproduce the contents of this publication, either in whole or in part.

UNCONDITIONAL GUARANTEE. The publisher, on written request, agrees to refund the part of the subscription price applying to the remaining unfilled portion of the subscription if editorial service is unsatisfactory. PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.
POSTMASTER Please send form 3579 to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St., New York 36, NY.

polished metal surface was of better quality than a dull surface. This theory is still held by some craftsmen, but about 15 years ago one of the country's research labs proved otherwise.

The director of research was given a highly polished flat spring (p 83) that would break when flexed only about 2000 times. Experimenting with this spring, the laboratory tried bombarding the polished surface with thousands of tiny bits of steel shot—an effect similar to the pounding of the blacksmith's hammers. This strengthened the spring so that it could withstand more than 2 million flexing cycles without breaking. However, in the process, the spring lost its polish. Thus by a modern version of an old art engineers found a case where the metal product with the dull surface far surpassed its shiny counterpart.

Takes Two to Tunnel



For the past 150 years, engineers have been talking about digging a tunnel between France and England. But the politicians have yet to reach an agreement and, until they decide, present plans cannot reach the final design stages. The first political problem arose in 1802 when Mathieu Favier approached Napoleon Bonaparte with a plan to cross the 21-mile English Channel by digging a tunnel from each coast. They would meet at a man-made island. Napoleon was most enthusiastic, but negotiations with England broke down and the plan was dropped.

But though the two governments were marking time, British engineers were making history with underwater tunnels at home. In 1825, Marc Brunel began constructing a 1200-ft tunnel under the river Thames. It took 18 years to build and was a flop financially but it is still in operation today as part of London's underground (subway) system.

In 1880 the England-to-France tunnel project got off the drawing board, but not for long. Shafts were sunk on each side of the Channel, and work went ahead on two pilot tunnels. They were inspected by Queen Victoria, the Prince of Wales, and Prime Minister Disraeli. Newspapers around the world hailed this great engineering achievement that was about to be launched. Englishmen and Frenchmen were looking forward to completion around 1887. And then someone at the British War Office nervously advanced the idea of a mass invasion coming through the tunnel. That did it! The project stopped dead in its tracks; England and France were left with their two huge shafts idly waiting for another attempt to unite the European continent with the British Isles. When that day comes, the tunnel-car described on page 61 might come in handy, making it easier for bobbies and gendarmes to patrol their beat under the Channel.

—Benedict A Loerburger Jr

SIDELIGHT

The automated postoffice isn't a year old and already there are ideas that would make it obsolete. Dr Arnold M. Levine, v-pres., Missile and Space Systems, ITT Laboratories, predicts electronic mailboxes that will "permit the letter-sender to deposit his letter, drop a coin in a box, dial the destination in the manner of a phone call, and have a facsimile transmitted by satellite." This system would work in conjunction with the "Earth Net Dial" system, by which a group of "stationary satellites" can relay signals instantly around the earth. It's aptly called the END . . . Amen!

NEXT WEEK IN PRODUCT ENGINEERING

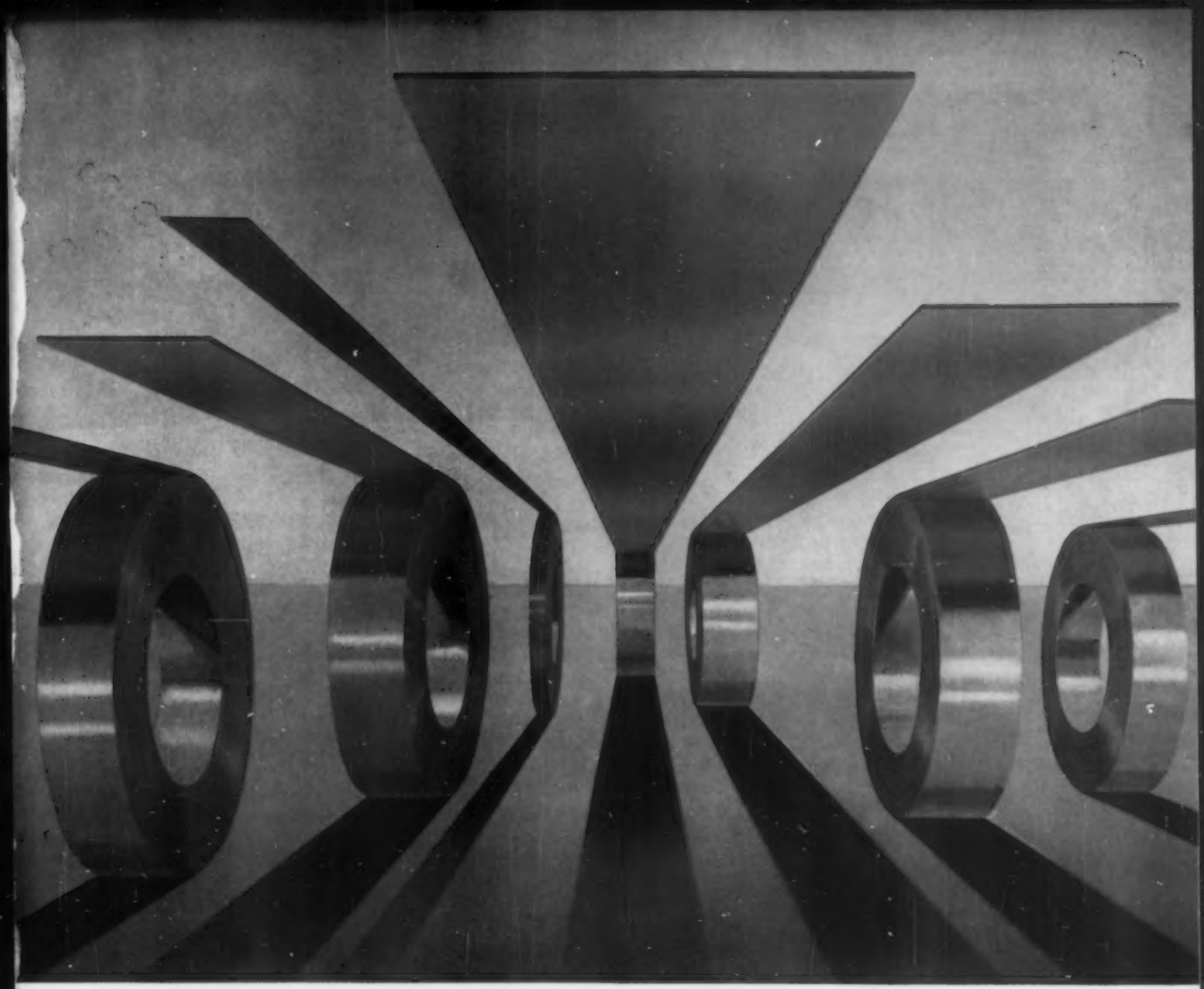
. . . **New Criteria for Measuring Fluid Contamination**
Available measurement techniques—many of them new—are compared with the generally accepted standard.

. . . **Electromagnetic Clutches and Brakes for Automatic Control**
Design information on the three major types—with sketches of 10 designs and 12 applications—to help you make the right choice.

. . . **Welding or Brazing Dissimilar Metals**
No leakage at high pressures—that's a challenge to integral joints between two different metals. Here's your design information.

. . . **Gyroscopic Machine Yields Better Fatigue Data**
New version of rotating-beam tester uses gyroscopic moments to induce bending stress in specimen.

. . . **How Cutouts and Braces Affect Machine-tool Tables**
Comparative stiffness values for 30 designs.



WHAT'S DIFFERENT ABOUT J&L PRECISION STRIP STEEL?

The big difference in J&L strip steel is controlled uniformity.

When J&L Precision strip is ordered to exacting specifications, you can be sure that your specifications will be met . . . inch after inch, coil after coil, time after time.

The dimensional accuracy of J&L strip steel, consistently maintained, offers many cost-saving advantages. This means fewer rejects; fewer production problems; less down-time for tool adjustment. This means that you are getting the steel you pay for . . . in terms of maximum product yield per ton.

How?

By delivering the steel you order . . . to your specifications . . . J&L helps you to achieve optimum production with control of in-plant fabricating costs.

The experience, facilities, and accumulated know-how of a specialized organization . . . directed exclusively to the processing of low carbon, high carbon, alloy, tempered and stainless strip steels . . . are available to work for you. For assistance in solving your problems, call your J&L Stainless and Strip Division representative; or write to Dept. 233-Y-1216.

J&L STRIP

LOW CARBON • HIGH CARBON • ALLOY • STAINLESS
TEMPERED SPRING STEEL • ZINC AND COPPER COATED

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

CIRCLE 5 ON READER SERVICE CARD

DEVELOPMENTS TO WATCH...

Pump-motor system recovers "lost" energy

Development of a regenerative power unit for hydraulic presses has cut the size of the drive motor needed by as much as 50% and reduced capital and operating costs as well. Britain's National Engineering Laboratory, which designed the unit, says it reclaims the energy normally taken up by the press frame and wasted by compressibility of the hydraulic fluid.

In the new system, a high-pressure pump serves as a hydraulic motor during the exhaust cycle to reclaim the "lost" energy and apply it to the next power cycle. The surge of pressure that normally goes back to the suction vessel drives the hydraulic pump-motor (*PE—Nov 14, p 8*) and is stored as kinetic energy in a flywheel mounted between the electric driving motor and the pump. With this system, says NEL, "the hydraulic circuit is simplified and costs are reduced. The driving motor needs only to be large enough to supply the average power of the cycle."

A prototype model has been applied to a rubber-bag-type dewatering press for wool. A double-acting cylinder, operated on one side by hydraulic fluid from a motor-driven oil pump, applies pressure to a water-cylinder piston. This fills a rubber bag that squeezes against the wool which is placed between the bottom of the bag and a perforated platen. On completion of the pressure stroke, a changeover valve relieves the pressure on the wool and reverses the piston movement. But instead of returning directly to the reservoir, the fluid goes back through a series of valves to the pump, which then acts as a motor, increasing the speed of the driving unit. This unit is now to be made commercially, and further development is in progress.

Nickel-free brasses and steels developed in India

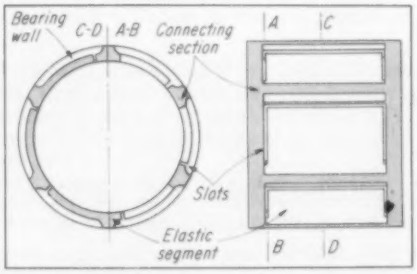
Austenitic stainless steels that contain little or no nickel, and nickel-free brasses that compare favorably with "nickel silver," are reported by India's National Metallurgical Laboratory. They're first in a series of new materials being developed to minimize use of elements scarce in India and take advantage of those which are abundant.

Key to both groups of alloys is substituting manganese for all or part of the nickel. The steels are chrome-manganese-copper alloys with relatively high nitrogen content, and the "nickel silvers" are copper-manganese-zinc alloys.

The steels, NML says, show good oxidation resistance and creep resistance at elevated temperatures. They can be work-hardened, and develop "extremely high tensile strength, with satisfactory ductility." Electrical and magnetic properties are also of interest. Resistivity is about 75 micro-ohm/cm; saturation induction, less than 2500 oersteds for a magnetizing field of 2340 oersteds. Average permeability is 1.05.

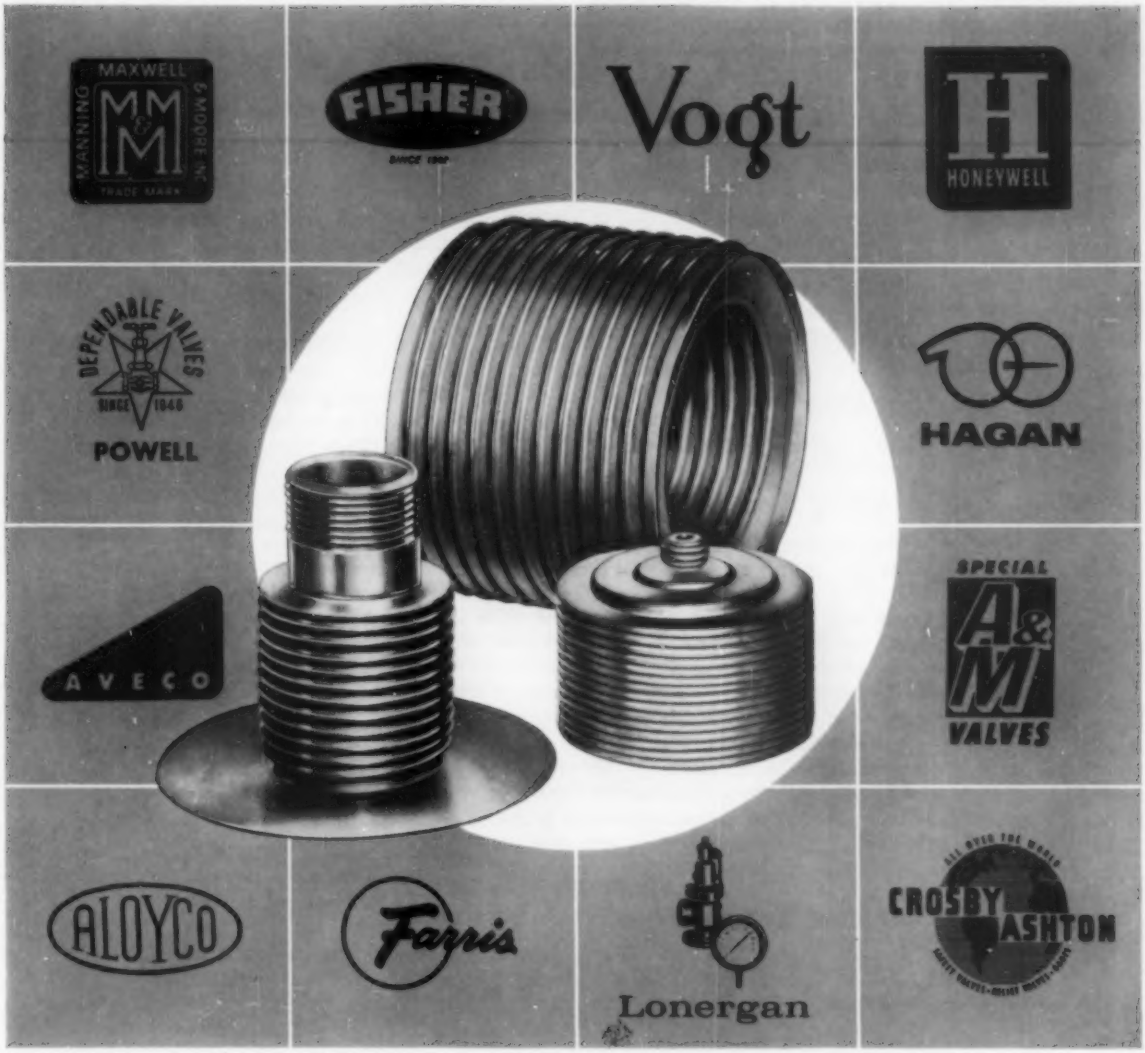
Iron-chromium-manganese-nitrogen master alloys are now being developed to put this material into commercial production. The "nickel-silvers" are copper-manganese-zinc alloys which, NML says, show promise as coinage metals, with "excellent forming and minting properties."

Grooves damp vibration of bearings



Milled, U-shape slots (see diagram) that break an oil film into wedge-shaped sections will help reduce flow turbulence and permit continuous high-speed shaft operation without bearing damage, Czech engineers claim. The slots form "elastic segmental portions that move outward under oil pressure during rotation, producing wedge-shape gaps through which the oil can pass." In this way, they say, self-excited vibrations are eliminated. The design—covered by Czech patent 87,116 and Austrian patent 196,181, to A. Tondl of Prague—is claimed to be less expensive and more effective than other oil-diversion systems developed for similar purposes.

continued, p 8



The country's leading valve manufacturers select **Flexonics** bellows for reliability and long life

To isolate contaminants, resist corrosion, assure reliable sealing and minimize servicing—leading valve manufacturers are adopting bellows for packless valve stem seals. Experience has proved the reliability and longevity of a bellows for performing this function, and Flexonics is the leading and most experienced supplier of bellows to this industry.

However, valve seals are but one illustration of the growing applications of bellows where high pressures, high temperatures, severe corrosive conditions and other complex problems are involved. Perhaps a bellows can be the answer to your design problem. The Flexonics Application Engineering Staff will be pleased to study your specific problem and make recommendations. Or, if you prefer, write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.

B-535

Flexonics
corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

EXPANSION JOINTS · METAL HOSE · SYNTHETIC HOSE · BELLOWS · AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

FLEXONICS CORPORATION
1351 South Third Avenue
Maywood, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.

Anodic coats to aid titanium

Anodic titanium coatings that reduce corrosion and also provide lubrication are being developed by several companies.

Titanium Metals Corp has recently patented an improved coating system which, it says, produces an oxide layer that will protect titanium not only from ordinary sources of corrosion but also from halide salts at temperatures to 1000 F. The treatment involves an ammonium phosphate aqueous solution and standard electrolytic equipment. It produces a dense, brown coating that can be further sealed by steam treatment.

An anodized coating that serves as lubricant is claimed by Rohr Aircraft. Here, the major aim is to ease hot-forming in the 700 to 1000-F range; but Rohr says, the coating can also be used to prevent "seizing" of titanium fasteners.

This one uses an alkaline fluoride solution, and produces a coating which, like an ordinary lubricant, is readily removed.

New magnetic materials promise high strength at low cost

Manganese-aluminum magnets may give the well-known barium ferrite ceramic materials a run for their markets one of these days, Crucible Steel researchers believe. Tests have shown that the intermetallic compound—53.5% (by atomic weight)—will develop an intrinsic coercive force on the order of 4500 oersteds. Maximum energy products (BH_{max}) as high as 3 to 4 million gauss-oersteds have been measured.

One of the most interesting things about the manganese-aluminum material, Drs R. B. Campbell and C. A. Julien of Crucible report, is the mechanism by which it operates—an order-disorder system involving strain anisotropy, instead of the more-usual shape-anisotropy systems. Of the older magnetic materials, only the cobalt-platinum group shows a similar effect.

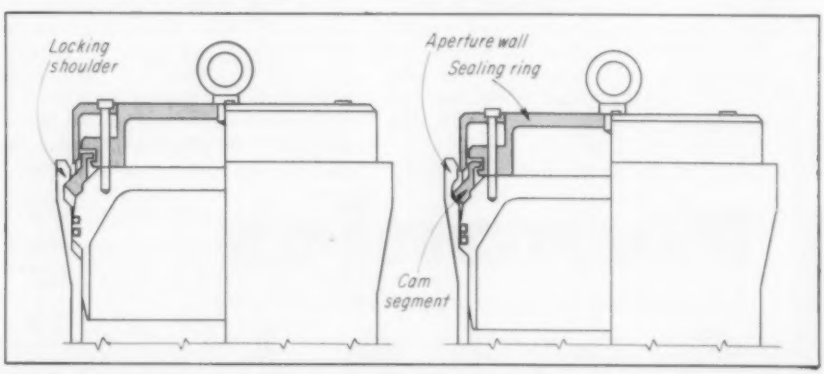
The new magnets are not yet ready for commercial introduction. For one thing, they are still very brittle; and more work is needed on the heat treatment that develops their ferromagnetism. But as of now, they do seem worth investigation.

Simplified plug has dual locking action

A plug-type closure that locks itself in place as it is seated, and provides a secondary adjustment when internal pressure is applied, has been designed by Geartight Unions Ltd, Middlesex, England.

It consists of a series of cam segments inserted in a sealing ring in such a way that, as plug is seated in an aperture, the locking-cam segments move out to engage the aperture wall. Then, when internal pressure is applied, the cam sections back out just enough to engage a shoulder provided at the edge of the aperture (see diagrams). The company says the cam segments show no marking after 1000 pressurized locking cycles, and can be applied to piping systems on molding presses and similar equipment.

Stanat Mfg Co, Westbury, NY is the US representative. —ARG



AS PLUG IS SEATED, cam sections move out to engage aperture wall (top). Secondary locking action is provided as internal pressure forces cam against shoulder (bottom).

WHAT'S HAPPENING IN RESEARCH . . .

Another space problem—sublimation in thin air

The high-vacuum conditions of outer space will make many materials "disappear" by vaporization, and markedly degrade others, recent studies indicate.

As R. A. Lad of Lewis Research Center points out, vaporization may cause damaging loss of thickness, change in frictional properties, and variations in emissivity. Particularly sensitive are high-purity metals.

But there are ways to get around the problem. There is evidence that sublimation at ultralow pressures can be reduced considerably by alloying and may also be controlled by formation of an oxide layer on the metal surface. The effectiveness of such layers on different metals at different temperatures seems to vary widely, however. On aluminum, for instance, a nonporous oxide layer forms very rapidly, even at low temperatures and very low oxygen pressure; while oxide formation on magnesium is much slower, and the oxide layer tends to be porous. Thus, the rate of vaporation of aluminum at a temperature halfway to its melting point differs from that of ultrahigh-purity magnesium at a similar point by a factor of 10^{20}. Furthermore, the actual melting temperature of the metal seems to make little difference. Chromium at its halfway point sublimes just as rapidly as magnesium at the same relative level.

In general, decomposition and vaporization rates seem lower for ceramics and other inorganics than for metals. But very little data is as yet available.

With plastics, there are problems of plasticizer loss and decomposition that may result in drastic changes in properties. Major studies of behavior of plastics in high vacuum at high and low temperatures are now under way, under Air Force and NASA sponsorship, and information on this aspect of the problem should be coming out within the next year.

Preliminary results from one study, by Kenneth A. Ray, now of Hoffman Electronics Corp, indicate that a substantial reduction in weight-loss can be achieved by proper selection of fillers (as might be expected, mineral fillers are less likely to sublime than organics), and that coatings, too, may help to reduce weight-loss and minimize changes in emissivity.

Note: A table of vaporization rates for 13 Space Age metals at 50% and 70% of absolute melting point in high vacuum may be found in NASA report TND-477, available from that agency in Washington, DC.

Soviet engineer reports on servo clutch design

With electromagnetic clutches built from powdered-metal parts, reversing systems for automatic control applications can be built to deliver a speed-control range of 1 to 50. Furthermore, they show linearity of performance and fast response to acceleration. And, says T. A. Glazenko in the Soviet publication *Elektrichestuo* (issue #4, 1960), the clutches are relatively lightweight.

One such unit, comprising two clutches, with separate excitation windings (sectionalized and tapped to 3 slip rings), a common amplifier, driving motor, tachometer, and actuating mechanism, has a rated torque of 14 kg/cm with a driving speed of 1070 rpm. This unit operates on 400-cycle power without separate transformers, by virtue of germanium diodes through which auxiliary windings are connected.

One problem: The ratio of torque to magnetic flux in the gap of the clutch is somewhat erratic owing to mechanical hysteresis in the powdered-metal composition.

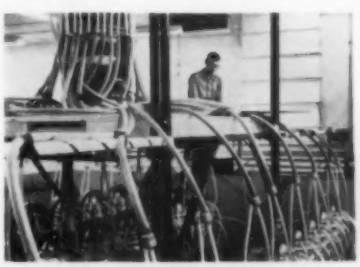
briefs . . .

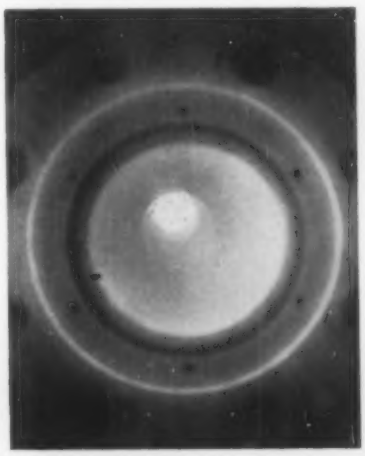
A line-voltage and noise monitor that correlates spurious instrument response with power-line disturbances, and can also serve as a momentary power-outage indicator and an expanded-scale recording voltmeter, has been designed at Phillips Petroleum Company's Atomic Energy Div (Idaho Falls). The aim: to eliminate sources of error in electronic amplifiers and pulse counters.

According to T. J. Boland of Phillips, the monitor responds to transients over the range from 1 microsec to 1 millisec; and as an expanded-scale recording ac voltmeter it is easily read to 0.03 volts. Full details on construction and use are contained in a 20-page Instruments Report (IDO-16608), being made available through OTS, Dept of Commerce, Washington 25, DC. Price: 50¢.

Take a look at 30 million degrees

To create a controlled thermonuclear reaction that will be a net energy producer, it's estimated temperatures on the order of 100 million deg C will be needed. They haven't been achieved yet. But, as these pictures show, scientists are on their way. With thirty 100-kv capacitors feeding energy to a thermonuclear machine and developing a magnetic field of 115,000 gauss, Los Alamos researchers have heated and compressed deuterium gas to an estimated temperature of 30 million C. Photo at left shows capacitor bank; below, the ultrahot gas can be seen inside its aluminum oxide containment tube. —ARG





WHY THIS IS A BETTER *LATCHING* RELAY

Better? Yes, in several ways. Bifurcated Contacts, for example, give improved reliability, especially in dry circuits. Contacts will not open during vibrations of 30Gs, 55 to 2500 cps. A special method of sealing cover to base eliminates flux contamination of the contacts. And there are more. Here is Potter & Brumfield's newest member of a distinguished family of micro-miniature relays: the FL Series.

Expressly designed for printed circuit applications, this DPDT, 3 amperes (@ 30V DC) latching relay lies parallel to the mounting surface. Its height, when mounted, is only .485", thus circuit boards may be stacked closer. Mounting can usually be accomplished without studs or brackets, simplifying installation.

The FL will remain firmly latched in either armature position without applied power, a significant advantage where power is limited and long relay "on" times are required. This relay may be operated by:

1. Pulsing each coil alternately (observing coil polarity), or
2. Connecting the coils in series and operating from a reversing (polarized) source.

Write for complete information or call your nearest P&B representative.

FL SERIES SPECIFICATIONS

Shock: 100 Gs for 11 milliseconds. No contact openings.

Vibration: .195", no contact openings. 10 to 55 cps. 30 Gs from 55 to 2500 cps.

Pull-In: 150 milliwatts maximum (standard) at 25° C. 80 milliwatts maximum (special) at 25° C.

Operate Time: 3 milliseconds maximum at nominal voltage at 25° C.

Transfer Time: 0.5 millisecond maximum at nominal voltage at 25° C.

Temperature Range: −65° C to +125° C.

Terminals: Plug-in pins.

Dimensions: L. 1.100" Max.—W. .925" Max H. .485" Max. Hermetically sealed only.

SC 11 D

SCG 11 DC

SL 11 DB (Latching)

SLG 11 DA (Latching)

Other P&B micro-miniature relays include conventional and latching models in crystal cases with a wide range of terminals and mountings. All are made in a near-surgically clean production area under the exacting requirements of our Intensified Control and Reliability program.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

YOUR BEST SINGLE SOURCE FOR ALL MICRO-MINIATURE RELAYS

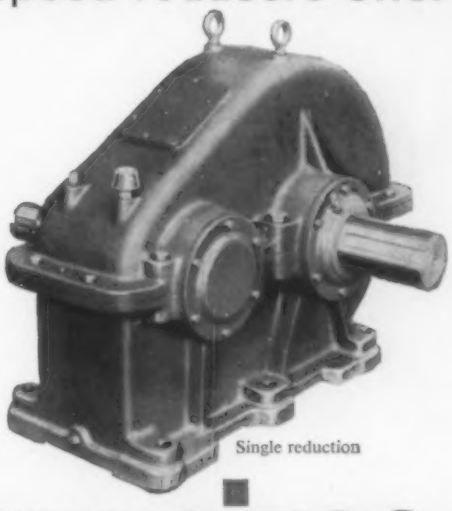
POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

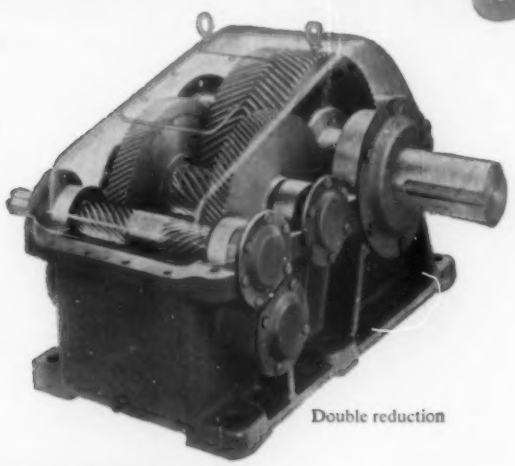
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

NOW Link-Belt parallel shaft speed reducers offer

new design



Single reduction



Double reduction

new sizes

new ruggedness

Triple reduction

reduce drive costs by matching drive size to horsepower requirements with 35% more sizes

New design—Herringbone or double helical gears arranged in new "balanced" design permit high horsepower, high ratio reduction in a sturdy, compact housing.

New sizes—Now 18 sizes each of double and triple reduction units; 17 single. Drive selections closely match hp requirements, with a corresponding reduction in drive costs. Available to 2800 hp, ratios to 292:1.

New ruggedness—Rigid, ribbed housing keeps parts accurately and permanently aligned even under grueling operating conditions involving heavy shock loads, and temporary overloads.

For complete information call your nearby Link-Belt district sales office. Ask for Book 2719.

OUTSTANDING FEATURES

- Grease-lubricated seals.
- Positive splash lubrication supplies ample flow of oil to all moving parts.
- High-capacity spherical roller bearings for maximum loading.
- Gears of hardened, precision alloy steel. Double helical or herringbone design.
- New, built-in backstop.
- Exceptional wearing qualities in accurately machined low-speed shafts of heat-treated carbon steel; intermediate shafts of chrome-molybdenum steel.
- Cast iron housing maintains permanent, accurate alignment of all parts.

LINK-BELT

SPEED REDUCERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15.3E

←CIRCLE 10 ON READER SERVICE CARD

CIRCLE 11 ON READER SERVICE CARD 11

REPUBLIC
COLD EXTRUSION QUALITY
STEEL

. . . steel that cuts your cost of production

Republic Steel—largest producer of the nation's widest range of bar products—has a new, 11″ bar mill in Chicago that specializes in steel for cold extrusion and cold heading. Features that save you money:

1 **UNIFORM FLOW CHARACTERISTICS**—carbon and alloy steels produced on this mill have denser, more uniform structures because they undergo more hot work. Bigger than usual billets, 3″ and 4″ square, become finished products of standard size.

2 **PRECISE DIMENSIONAL ACCURACY**—16 alternating vertical and horizontal stands with roll neck bearings are utilized to exert uniform pressure on all sides of the bar. This process, along with vertical looping above the mill, eliminates deformations.

3 **ANNEALED, NORMALIZED, SPHEROIDIZED**—new continuous annealing furnaces, capable of all types of furnace treatments, are designed for rigid control of speeds, temperatures, and atmospheres. Other facilities are available to pickle, oil, lime, phosphate, and borax coat bar products.

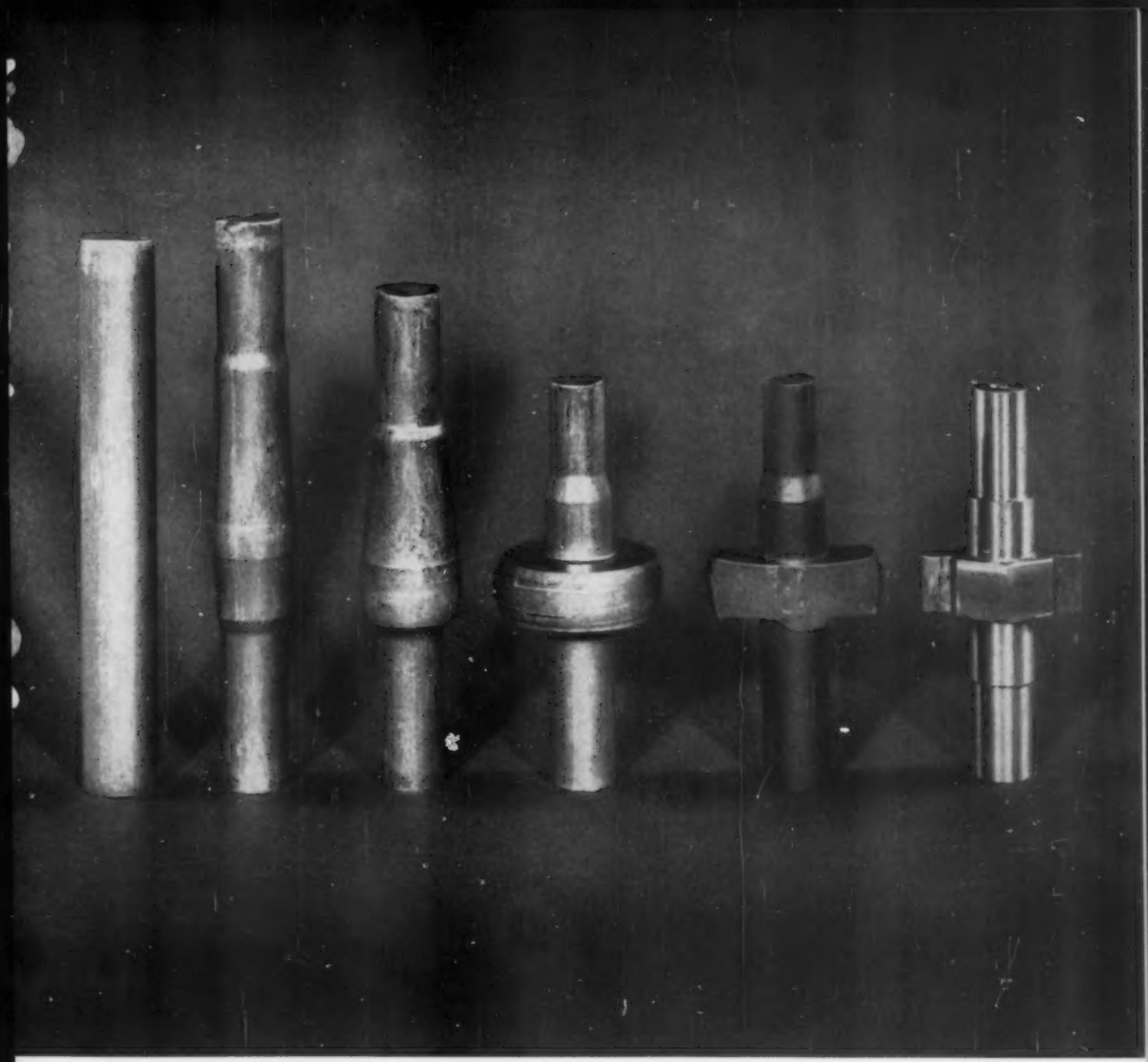
4 **1600-POUND, DOUBLE-BANDED COILS**—four high-speed coilers handle the complete range of coils produced (⅜″ to 3⅜₆₄″—700 to 900 pounds, ⅝″ to 1½″—1400 to 1600 pounds). Bigger coils cut downtime and scrap loss. Double banding simplifies your handling.

5 **CAPACITY TO MEET YOUR REQUIREMENTS**—this 11″ bar mill produces bar products at rates of up to 3000 feet per minute. Annealing furnaces are the continuous type, capable of meeting the growing demand for furnace-processed steel.

COLD FINISHED, TOO!

Depending upon the nature of your product and the method by which it is made, you may find it more advantageous to use cold extrusion quality steel in *cold finished form,* as did the manufacturer of this gear.

We would welcome an opportunity to serve you on your requirements for both hot rolled and cold finished, cold extrusion quality steel. Our metallurgists will help you select the most economical carbon, alloy, or stainless steel capable of meeting your requirements. For complete data, call your nearest Republic sales office or mail the coupon.



CUTTING THE COST OF A SEGMENT GEAR: ideal blanks are produced by cold heading, cold extrusion, and upsetting. Stock with upset in the center is hot trimmed on a press, after which it is machined into the finished part. Only a minimum of stock need be removed during final machining. Photo courtesy of National Machinery Company, Tiffin, Ohio.

REPUBLIC STEEL

REPUBLIC STEEL

World's Widest Range

of Standard Steels and Steel Products

Strong, Modern, Dependable

REPUBLIC STEEL CORPORATION
DEPT. PS-1131A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Send more information on cold extrusion and cold heading quality steel.

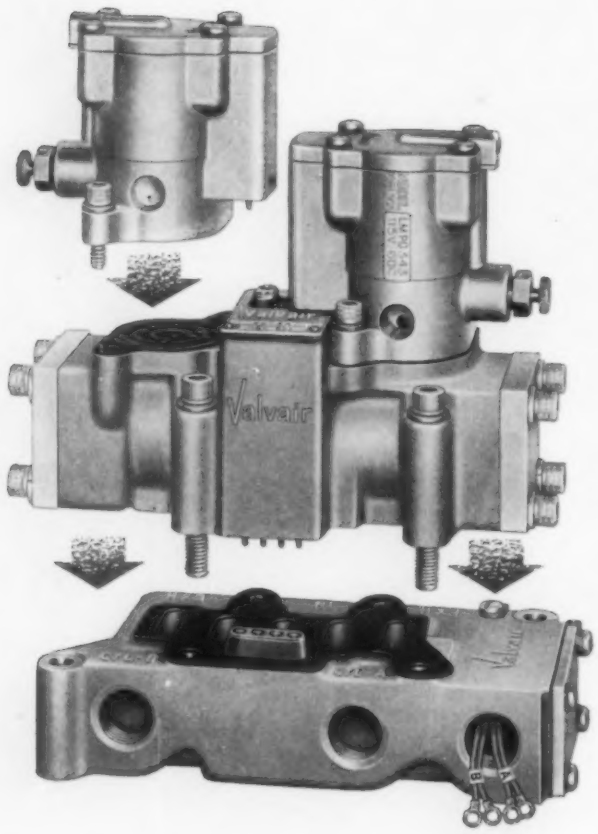
☐ Hot Rolled ☐ Cold Finished

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____



VALVAIR®
½" NPT
PLUG-IN
VALVES

MODEL PD-441 shown. 4-way single or double pilot-operated types, for sub-base or manifold mounting. Aluminum and stainless steel components assure multi-million cycle dependability. Interchangeable pilots, with coils guaranteed against burn-out for life of valve, fit any plug-in Speed King. Coils for ac or dc, any voltage . . . 35 — 200 psi range . . . integral junction box . . . optional manual over-ride, common or separate exhaust ports, sub-base connected external pilot supply . . . ¾ in. exhaust ports, ½ or ¾ in. inlet and cylinder ports . . . valve meets JIC standards.

Based on the service-proved design principle of the Speed King ¼ in. plug-in Valvair's ½ - ¾ in. plug-in valve series provides plug-in convenience and versatility to a wider range of control valve applications.

Electrical and pneumatic circuits are completed automatically when valve and pilot are plugged in . . . bolted down. The result — cost-cutting reduction of original installation and maintenance time. All power connections are made permanently in sub-base or manifold . . . there's no need to disturb piping or wiring for quick in-service maintenance.

What's more, advanced design shortens stroke . . . speeds response. Separate coded (4-wire) circuits on double solenoid models meet JIC requirements. Flow area through valve and sub-base equals that of full ½ in. pipe.

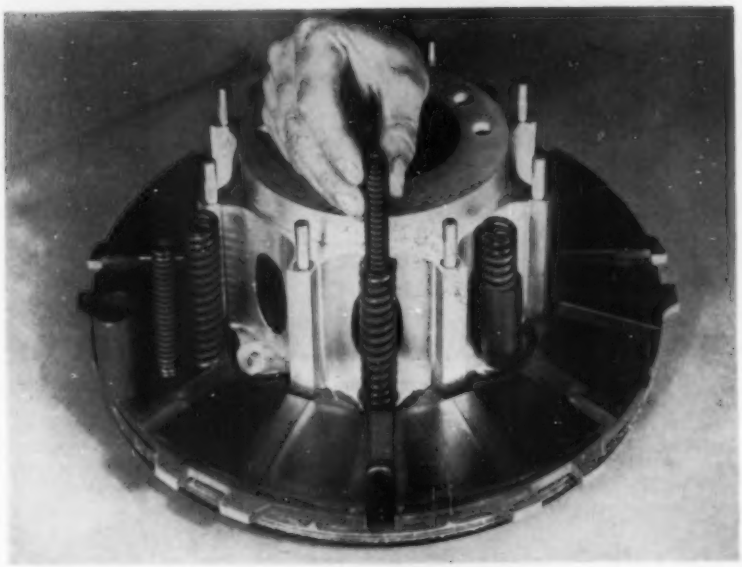
Whether your control valve applications are on the drawing board or now in service, it'll pay you to investigate the advantages of Valvair plug-in design. A call to your near-by Valvair field office will bring prompt application engineering recommendations.

For more information, write for Bulletin SPL. Address Dept. PE-1260 Bellows-Valvair, Akron 9, Ohio

Bellows-Valvair
AKRON 9, OHIO
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

8098-3

THE ENGINEERING WEEK



SIX COAXIAL SPRINGS made from NS-A286 are encased in protective metal shields and spaced around center of the brake disks. A McDonnell F4H-1 interceptor fighter has two of these brakes.

Superalloy Gives Better Brake-return Springs

MILES, MICH—An austenitic superalloy wire called NS-A 286 will be used in the return springs of aircraft brakes for the F4H-1, Mach 2 Navy interceptor fighter plane. According to National-Standard Co metallurgists who introduced the alloy and Auto Specialties Mfg Co engineers who make the brakes, NS-A 286 has better stress-temperature stability up to 1000 F than any other available alloy, yet costs only half as much as the next best alloy.

When this plane's brakes are released, function of the return spring is to separate the stationary stator disks from the moving rotor disks. When the brake is applied, its disks change all kinetic energy of the moving plane to heat—thereby bringing the plane to a stop. Heat in the stacks of disks can rise to 1400 F. The return springs are barely ¼ in. from these hot stacks, shielded only by a thin metal cylinder.

The F4H-1 has two such brakes; each has 6 coaxial return springs, (photo above). The inner springs are made of 0.0915-in. NS-A 286 wire, left-hand coiled into 23 total coils; each spring is about ½-in. dia and is 2.167 in. long when fully compressed or 2.845 in. long at max working length. Outer springs are made of 0.135-in. wire, right-hand coiled into 15 total coils. This spring is about ¾-in. dia. Its lengths are the same as those of inner spring. Tolerance on the spring wire dia is ±0.001 in.

A portion of the 1400-F heat built up in the disks is quickly absorbed by the return springs, raising their temperatures to as much as 1000 F. The springs must retain their strength at this heat to remain effective; otherwise brake drag would build up, possibly causing wheel or tire failure during landings.

Because the plane may taxi up to 5 miles and takeoff speeds are high, return springs must also keep brake disks from dragging against each other to prevent heat damage and attendant failures during this tough duty.

A tailored combination of heat-pressing, annealing, and reduction was specially developed to obtain desired relaxed lengths, to minimize set at high temperature and high stress, and to permit machine-coiling.

Considering physical properties alone, Ausco's aircraft-brake engineers say, full annealed wire would have been best. To prevent galling during automatic coiling, however, 9% reduction was chosen to coat the wire surface with a lubricant.

After coiling, the springs are precipitation heat-treated at 1350 F for 16 hr. Then they are hot-pressed at 900 F for two hours while held at a length between solid compressed and the maximum working length (between 2.167 and 2.845 in.). Ends are closed and ground flat within 3°.

Max stress develops with fully worn brakes, when the springs are compressed to their minimum length of 2.217 in. The outer springs then develop 119 lb (109,200 psi) load at room temperature of 72 lb (66,000 psi) load at 1200 F. Corresponding test loads on the inner springs develop 65 lb (120,200 psi) at room temperature and 40 lb (75,000 psi) at 1200 F. These loads are well above those required to separate the disks.

Min spring loads are maintained up to 1000 F with new brakes—100 F beyond actual service conditions. Even though relaxation may occur, the springs will always maintain necessary release pressure against back pressure.

NS-A 286 is a precipitation-hardening alloy giving as little as half the percent relaxation loss at 1000 F as comparable alloys at 850 F. It is made of 24 to 27% nickel, 13.5 to 16% chromium, 1.75 to 2.25% titanium, 1 to 2% manganese, 1 to 1.5% molybdenum, 0.4 to 1% silicon, 0.35% (max) aluminum, 0.1 to 0.5% vanadium, 0.08% (max) carbon, 0.4% (max) phosphorus, 0.03% (max) sulfur and 0.001 to 0.01% boron. Balance is iron. ■

Engineering Teachers Report Salary Increases

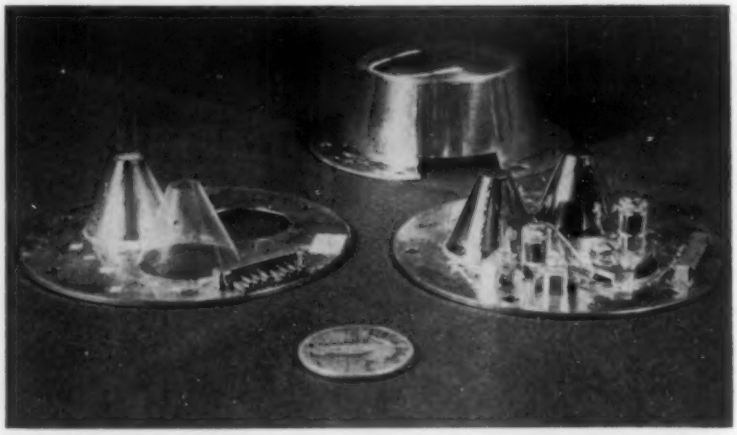
NEW YORK—Average total professional income of engineering teachers has increased by 14.7% in the past two years, according to the Engineering Manpower Commission of the Engineers Joint Council. The commission bases its statement on a survey of 5000 engineering teachers—about half the total.

A large proportion of total engineer-

ing teacher income—77.5%—is accounted for by the basic teaching salary. The remainder comes from outside professional work such as consulting and research. Since the first of these surveys was made in 1956, average basic teaching salaries have risen 31.1% and income from outside sources, 11.3%. The average salary today is $8534, according to the Manpower Commission.

In public institutions, the rise in total income was 15.6%, somewhat greater than the rise of 12.5% in private institutions. More outside earnings and a rise in basic teaching salaries contributed to the better showing of the public institutions. Basic teaching salaries increased 13.4% in the public schools compared with 13.0% in the private; outside earnings increased 24.8% in the public schools compared with 11.3% in private institutions. ■

Radiometer for Tiros II



Measuring less than 3½ in. dia (contrasted with 25-cent piece in foreground) and requiring only 50 microwatts to operate, this 1½-oz radiometer is gathering data for Tiros II. It's a 5-channel instrument with a field of 6° by 6° (approximately equal to that of a narrow-view TV camera). Field of this radiometer, built by Barnes Engineering Co for NASA and the Army Signal Corps, is fixed with respect to the satellite; scanning is by Tiros II's own motion.

Safety Rules Provided for Nuclear Instruments

ZURICH—Recommendations for safety requirements in the field of nuclear instruments have been drawn up by the International Electrotechnical Commission (IEC).

The rules will apply to passive nuclear instruments containing electrical components in which peak voltages reach 34 v. (Passive nuclear instruments are defined as those which neither emit ionizing radiation nor contain radiation sources.) Included are instruments for the following tests: resistance to heat, mechanical strength, heating, protection against accidental contact, moisture resistance and insulation, operation in the event of defects. ■

Executive Pleads For Graduates Who Can Solve Problems

ANN ARBOR—It is inefficient for the graduate school to provide narrow, specialized training. Business can supply such specialization better and more efficiently, Theodore O. Yntema, financial vice-pres of Ford Motor Co, told the Univ of Michigan Conference on Higher Education here.

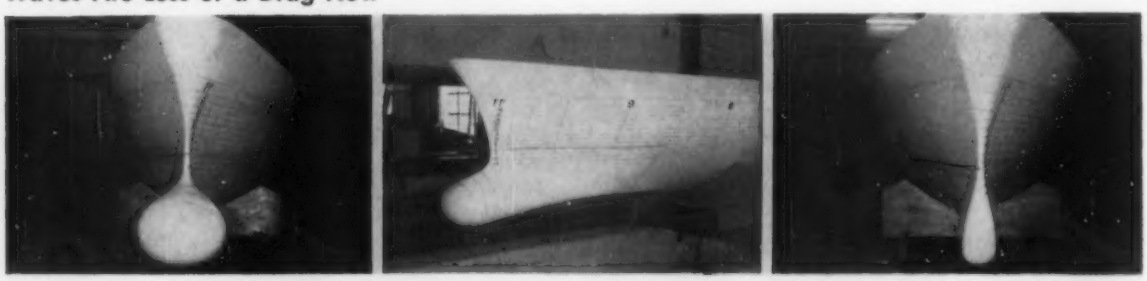
Business does not want people with trade-school training, who are lost as soon as they find themselves outside their narrow specialty, Yntema declared.

"What we in business do want from our graduate schools," he urged, "is physical scientists, social scientists, lawyers, and business-school graduates of high competence—people who can do more than repeat facts, and parrot theories, and tilt with hypothetical windmills.

"We need people who can deal with real problems—problems sometimes quite theoretical and abstract, and problems often beset by confusing factors and economic limitations; people who can see and solve problems and who can cooperate and communicate with others in the process. We do not want people who have been narrowed by their graduate training."

Yntema admitted that it is difficult to teach inventiveness, but added that such teaching is undoubtedly possible. Most education today, he said, discourages the process. One approach

Waves Are Less of a Drag Now



The drag effect of waves on ships—said to reduce a vessel's propulsion power by as much as 80%—is minimized by a device developed at Tokyo University. It consists of a webless form, shaped like a tennis racket, which is fitted to the bottom of the keel at the bow (left and center photos). This fitting sets up counter waves, reducing by about 10% the drag waves created by the ship's movement in the water. Photo at right shows conventional bow.

to nurturing the inquiring mind might be seminars on unsolved problems; which would provide opportunities for graduate students to find perhaps ten good thesis topics instead of accepting a part of a professor's research.

The Ford executive also suggested that high-caliber graduate students should become literate in mathematics (at least as far as differential equations), logic and statistics. And able students should become familiar with basic ideas in many sciences through a high-level course, learn to write acceptable English, and learn something about the process by which discoveries are made and problems solved. ■

Compact Truck Bids for Slice of Market

CHICAGO—International Harvester Co next spring will begin producing an all-purpose compact vehicle to be known as the "Scout," and designed to boost this company's position in the light-truck field. Harvester has long been the leading producer of large, heavy-duty trucks.

The new vehicle will be available with either two-wheel or four-wheel drive. Its wheelbase will be 100-in. and its over-all length less than 13 ft. It will be powered by a newly developed 4-cyl engine featuring both power and economy, according to Harvester. A variety of attachments including snowplows, winches and other equipment items will be made available for the Scout.

It will have an integral pickup body, a detachable hardtop cab and detachable doors. It will also be available with a detachable steel enclosure for both passenger compartment and load-space area.

Harvester engineers say the Scout can be converted in minutes to a completely open model without top, doors or windows, allowing a wide range of uses from passenger runabout to small pickup truck. No price schedule is available at this time, but the new vehicle is expected to be competitive with other vehicles of a similar type.

Although Harvester does not say the Scout is intended to compete with the Jeep, it has been known for some time that Harvester has been eyeing the Jeep market, both at home and abroad. ■

Introducing the 'Tunneltron'—Rival to Tunnel Diode

CAMBRIDGE, MASS—A "tunneltron" fabricated at Arthur D Little Research Laboratories is described as the first evaporated electronic component to show negative resistance.

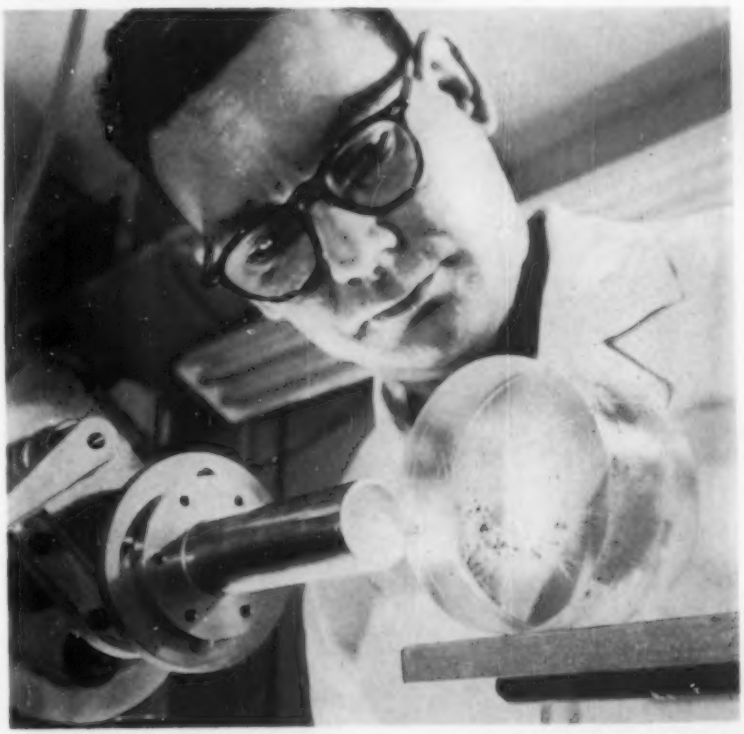
It was made by evaporating an aluminum strip onto a glass substrate, oxidizing it in air to form a thin surface layer of dielectric aluminum oxide, and then evaporating a thin cross-strip of lead on top of the aluminum oxide.

Devices based on the new discovery promise many advantages over tunnel diodes, including ability to control negative resistance and hence the operation of a device by applying a magnetic field. Another asset is extreme ease of manufacture and flexibility because the metal-dielectric-metal sandwiches are made by standard vacuum-evaporation techniques.

Unexpected "switchback-action," or negative resistance region, was found when current was passed through the sandwich at temperatures near absolute zero. Application of the negative-resistance phenomenon is expected to lead to development of an entire new family of simply constructed components compatible with present low-temperature electronic circuits. As cryotrons, tunneltrons may extend range of cryogenic circuitry to include low-noise amplifiers, high-frequency oscillators, and new types of switches and memory devices for computers. Tunneltron has very low power re-

continued on page 20

Flash-testing Missile Electronic Systems



A linear electron accelerator (called linac by its builders, Hughes Aircraft Co) produces world's first single-pulse, high-intensity burst of about 10,000,000 volts of gamma radiation—equal to an atomic explosion—in testing effects of nuclear radiation on Army missile electronic systems. While actual firing is done manually, control of the operation is maintained from a 10-step, semiautomated console. Hughes engineers say linac can sustain high currents for long pulse widths, achieving 0.4 amp at a 9-microsecond pulse. Machine is equipped with two 500,000-watt klystron tubes which inject microwave energy into the high vacuum of the 30-in. accelerator tube. Linac is expected to find application in connection with the use of atomic energy in such diverse fields as medicine, pharmaceutical processing, plastics, chemistry, physics and electronics.

THE MAN & THE DRIVES

FROM WESTINGHOUSE

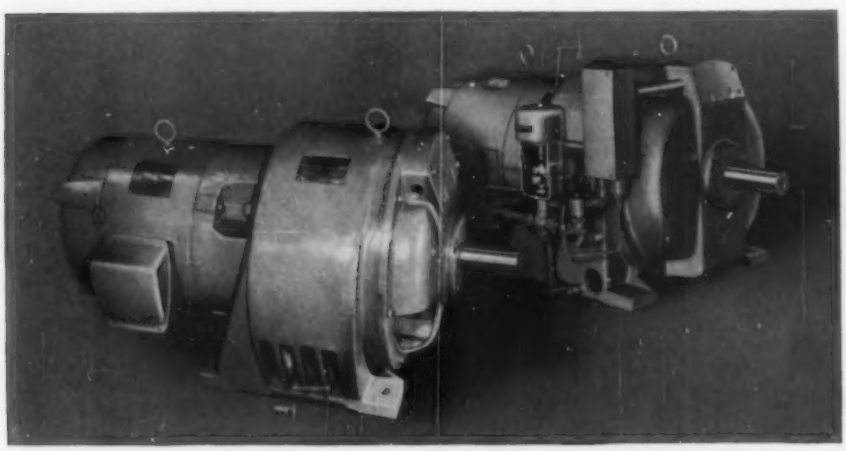
Mr. Westinghouse and MagnaFlow Drives Bring Simple Solution to Speed Control Problems, Save Money and Space, Too!

Westinghouse MagnaFlow* electromagnetic drives—air or liquid cooled—provide infinitely adjustable speeds from standstill to top speed with regulation guaranteed at $\pm 2\%$ of top speed over a 17-to-1 speed range (even closer regulation when desired). Control is smooth and stepless.

These compact drives, having a minimum number of parts, are built for rough, trouble-free service. The unique electromagnetic coupling maintains adjustable output speed without the use of pulleys, belts, brushes, commutators, slip rings or rotating windings. A rugged Life-Line® "A" motor supplies reliable a-c drive power. No power converting equipment needed—only a small, static exciter and an operator's control station. Initial cost is low; installation—easy and inexpensive.

Your Man from Westinghouse is ready now to help you apply MagnaFlow drives . . . and any other drives you may need. Call him . . . or write for a copy of Westinghouse MagnaFlow Electromagnetic Drives (B-7875), Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. You can be sure . . . if it's Westinghouse. J-22162

*Trade-Mark



MagnaFlow drives—air cooled (foreground) and liquid cooled—are available in various horsepower ratings for winders, conveyors, fans, pumps, extruders and other machinery in all industries.

Westinghouse

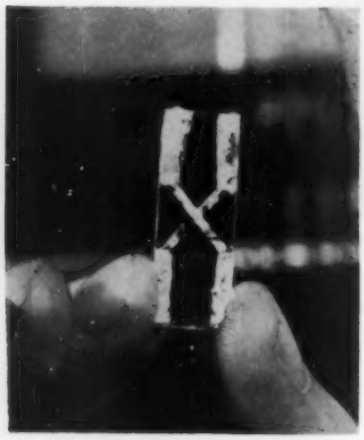
CIRCLE 19 ON READER SERVICE CARD

continued from page 17

quirements and should operate at very high frequencies. ADL scientists interpreted negative-resistance behavior in terms of modern theory of superconductivity which predicts that superconductive state is associated with change in energy of conduction electrons in metals.

—Paul Giguere, Boston Bureau

Tunneling Takes On Another Assignment



Application of electronic "tunneling" to devices of simple configuration has given General Electric a new approach to the construction of versatile microminiature electronic components. Devices such as shown above have two metal films separated by a thin insulating layer, with one or both of the films in the superconducting state. Functioning portion of the device is the point at which the two strips cross. According to GE, tunneling may lead to making a simple device that could function as a switch, a diode, a negative-resistance diode, triode, resistor or capacitor.

Extruded Panel Supplies Own Ducts

Production of these one-piece panels lined lengthwise with 24 internal parallel passageways is described as a metalworking first by Alcoa. Each panel has 24 voids, spaced ¼ in. apart within its 18½-in. width. Each opening measures ⅛ in. at its widest point, 7/16 in. high, and extends the full 65-ft length of the aluminum panels which are extruded on a 14,000-ton press using a special bridge-type die. Parts will be used to form cabinets that will house electronic equipment in high-altitude aircraft. Similarly extruded parts could find use in industries where flowing gases or liquids are required to overcome heating and cooling problems.

Chevy Readies New Engines for Smaller Compacts

BUFFALO—Chevrolet Div of General Motors is developing new aluminum block four- and six-cylinder engines with interchangeable parts for '62 models. The engines are being readied in a crash program following Ford Motor Co's announcement of production of a car smaller than the Falcon for 1962.

Originally scheduled for 1963, the four is reported to be a cut-down version of the new six—two of the cylinders are chopped off. (The 4-cyl Pontiac Tempest engine is produced in a similar way, *PE*—Sep 12, p 64).

The new six is said to be smaller and lighter than Chevy now makes for its standard cars.

—George E. Toles, McGraw-Hill News

McGraw-Hill Nears Merger with Catalog Publisher

NEW YORK—McGraw-Hill Publishing Co Inc has announced that discussions looking toward acquisition of the F W Dodge Corp are proceeding satisfactorily and an understanding is expected to be reached in the near future.

The Dodge company is an old and well-established publishing company with headquarters here. Its principal properties are Dodge Reports, a daily construction-news service; Dodge Construction Statistical Service; and Sweet's Catalog Service, which issues a number of catalog files of manufacturers' products. Other properties include *Architectural Record*, a professional monthly, and three commercial newspapers, *Daily Pacific Builder* (San Francisco), *The Daily Journal* (Denver), and *Daily Construction News* (Chicago). In addition, through a subsidiary, Dodge also publishes *The Modern Hospital, The Hospital Purchasing File, The Nation's Schools,* and *College and University Business.* ■

Radio Waves Cure Plastic

DETROIT — Radio frequency waves have found another job—curing the laminated sheet neoprene used for tank linings. The process, developed by Udylite Corp, is said to eliminate uneven curing and blister formation in the lining material. Previously, such blisters required a considerable amount of patching, which adversely affected life of the lining.

In the new process, the neoprene is rolled into the shape of a drum, which is placed within a retort. The retort is then pressurized and the rf generator and steam are turned on at the same time. The rf is kept on until the retort reaches equilibrium temperature, from which point the curing is continued by steam heat alone. ■

the editors
of
Product Engineering
are pleased to announce
the second annual

MASTER DESIGN AWARDS

for achievement in product development

A
program
to provide
recognition
for the engineers
and designers
of some of the most
significant
American products
of 1960.....

You may be eligible . . . details on next page

PRODUCT ENGINEERING **Master Design Awards**

Eligible

Products introduced in 1960, and designed and manufactured in the US. May be new or redesigned, but should be for quantity production and incorporate mechanical—and probably moving—parts, and use or transmit energy in some form.

Awards

Certificates of achievement to the **individuals** responsible for a selected design. There is no fixed number of awards; as many are made as are warranted by the caliber of the entries and the value of their contribution to engineering, design and product development in general. **Awards are to people,** not to companies (although companies are noted), and are not rated relative to each other. They will be made in Detroit in May, 1961, at the time of the Design Engineering Show, May 22-25.

Judges

A panel of seven men drawn from the Detroit area (last year it was New York, because the Show was there), including engineers, designers, educators and a consultant. Members of the 1961 panel are:

T R Diegel, manager, Machining Process Dept, Mfg Engrg Office, Ford Motor Co
Montgomery Ferar, partner, Sundberg-Ferar
Glen H Howell, professor of Mechanical & Industrial Engrg, Wayne State Univ
Stanley M Humphrey, partner, Booz, Allen & Hamilton
Aarre K Lahti, professor of Design, College of Architecture & Design, Univ of Michigan
J M Little, J M Little Associates
Kurt O Tech, vice president-Engineering, The Cross Company

Entries

Entry blanks are available from, and entries should be submitted to:
E J Tangerman, editor, Product Engineering, 330 West 42nd St, New York 36, NY.
Entries must be accompanied by a copy of the official entry blank and must be postmarked **not later than midnight, February 28, 1961. Elaborateness of presentation is not a factor in judging;** only the product and the development program will determine awards. However, drawings, photographs, samples of product or components and like supporting material may be submitted and will be returned when the judging is completed, probably about April 1.

Previous winners

Eleven products won awards last year, with certificates going to about one hundred men. Winning products were pictured and described in Product Engineering for May 23, 1960.

Write NOW for your entry blank to:
E J Tangerman, editor, Product Engineering, 330 W 42nd St, New York 36, NY
or **Write** "Awards Folder" on Reader Service Card.

CIRCLE 23 ON READER SERVICE CARD→

OPENING NEW HORIZONS

. . . in economical power application

98% PLUS OPERATING EFFICIENCY
MORE POWER PER CYLINDER DOLLAR
PROVEN LEAKPROOF OPERATION
GREATEST SELECTION EVER OFFERED
SAFE UNDER SEVERE LOADS
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS
SAFE UNDER TEMPERATURE EXTREMES
DAMAGE-PROOF PISTON RODS

Flick-Reedy . . . *Winner of "Plant of the Year" Award and "Silver Anvil" Public Relations Award*

Miller

MORE SAVINGS!

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an **extra 10% price savings** on our big "stock" selection of:
Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;
Model "A" (Air) Cylinders, 1½" through 14" bores.
Strokes up to 36", cushioned and non-cushioned.

Full Details On Request

Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shef" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

Write for literature.

R

MILLER FLUID POWER

DIVISION OF FLICK-REEDY CORPORATION

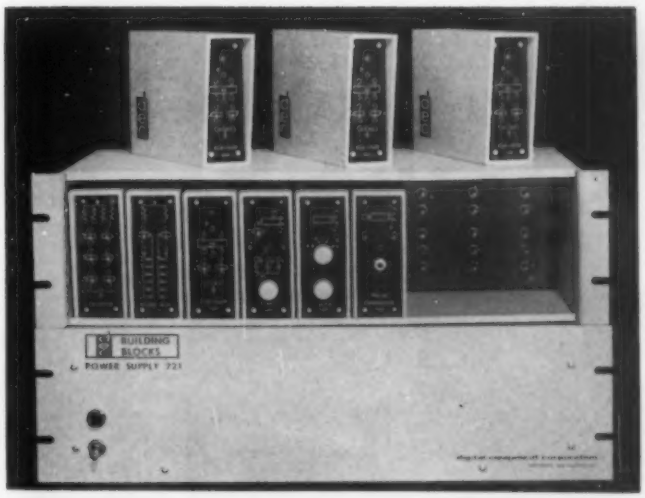
7N018 York Road, Bensenville, Illinois

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

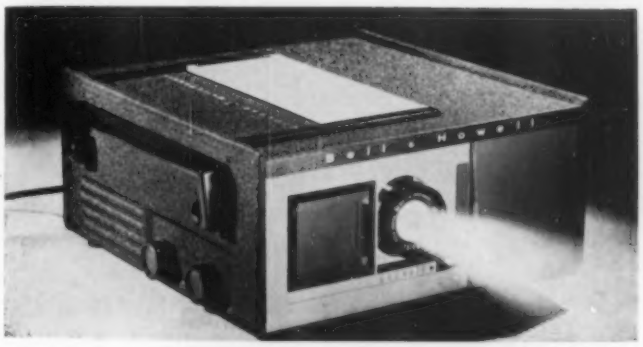
TWO-WAY RADIO for desktop installation has attractively simple cabinet shape, easily readable and accessible dials and controls, and what could have been a refreshingly clean front panel. Instead, Cadillac "V" symbol and vertical-line pattern provide lots of places for dust to collect. Manufactured by Motorola Inc, Chicago.

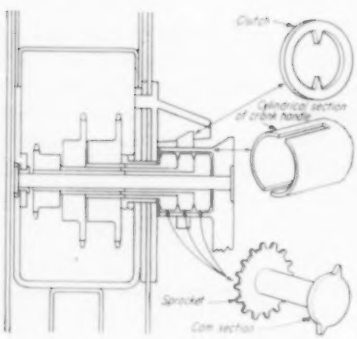
TRUCK CAB for French manufacturer Bernard was done by industrial designer Philippe Charbonneaux, who says he meant lines to imply those of TV receiver he designed (*PE/Sep 8, 58*). It certainly allows for plentiful air intake, but more than one US maker has done it better with less sheetmetal and bulk.

LOGIC-CIRCUIT KIT for educational, testing or developmental use is designed around building-block modules which plug in. Stacking-type banana-jack patch cords are used to connect various circuits, graphically represented on front panels. Counters, shift registers, decoders, adders, subtracters and other pulse apparatus are all housed in identical cases, inclined forward beyond front panels to provide integral grips. Manufactured by Digital Equipment Corp, Maynard, Mass.



PROJECTOR first projects slides onto a built-in, illuminated viewing panel so that operator can make sure slides are right side up. Then it automatically inserts them into tray, mixing 35 mm, bantam and super slides. Another gadget displays slide numbers through counter window. With all this sophistication isn't the black crinkle finish sort of a step backward? Manufactured by Bell & Howell, Chicago.

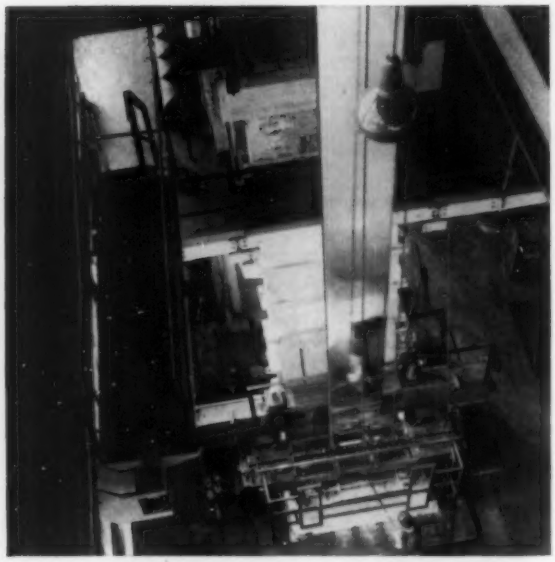


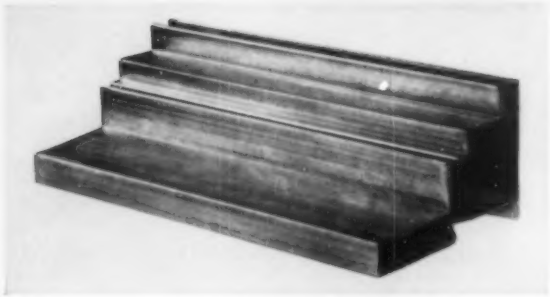


HOSPITAL BED'S head, knee or foot section can be raised or lowered by attendant or patient himself. This is accomplished with a single, 115-v ac, 80-in.-lb electric motor, whose power is transmitted through a chain-and-sprocket system, controlled by selector clutch (see drawing). Highly finished metal surfaces and sharp-angled styling are certainly in keeping with certain current trends in product design, but may not be good in a hospital bed, around which are performed a number of very active chores. Also, fixed crank handle, caster-brake lever and other protuberances are likely to prove good bruise-makers. Designed by A. Peter Augusztiny and B. F. Monroe for Furniture Dynamics Inc, Los Angeles.

ARMCO STEELS / for better products—lower costs

Here's Why Armco Can Help You Reduce Costs,





Uniform, full-weight zinc coating

Armco's special continuous hot-dip coating process produces a protective zinc coating that is uniform in weight and composition. Your products get most effective corrosion protection from such a coating. Standard coating on ZINCGRIP is 1.25 oz. class; however, you can specify heavier coatings, up to 2.50 oz. class, for applications requiring maximum protection. But no matter what the coating weight, Armco ZINCGRIP Steel's uniformity assures top-performance in production and service.

ZINCGRIP won't flake or peel

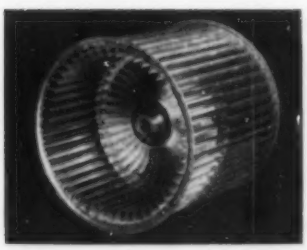
The ductile, adherent coating on ZINCGRIP takes any production drawing or forming operation without flaking or peeling. In fact, you can pull ZINCGRIP apart and the coating will adhere right up to the fracture. Best proof, however, is the fact that it has been used satisfactorily more than 25 years for thousands of severely drawn and formed parts. ZINCGRIP will go through your production line without trouble, give your products unimpaired low cost protection against corrosion.

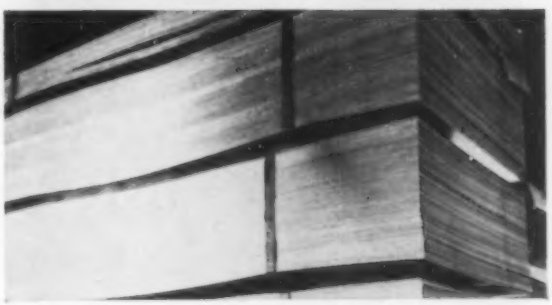
ARMCO STEEL CORPORATION
3180 Curtis Street, Middletown, Ohio
Send me data on the properties and fabrication of
☐ Armco ZINCGRIP Steel Sheets and Coils
☐ Armco ZINCGRIP Steel Tubing
Its use is contemplated for these products:_____
Name_____
Company_____
Street_____
City_____ Zone____ State_____

Use this hot-dip zinc-coated Armco Steel wherever you need low cost corrosion resistance. It gives you many possibilities for reducing your manufacturing costs and improving the performance of your products. For complete information on Armco ZINCGRIP Steel and how you can use it most effectively, just fill out and mail us the coupon.

New steels are born at Armco

ZINCGRIP Steel Improve Product Design





Eliminates need for plating or painting

For many parts requiring low cost protection against rusting and corrosion, Armco ZINCGRIP offers you opportunities to save money. ZINCGRIP Steel, available in sheets and coils provides you with mill-coated material that eliminates the cost and trouble of painting or plating. And the cost of this Armco zinc-protected steel is only a few cents more than cold-rolled steel. Many manufacturers find this small investment pays off in substantial cost reductions.

Available in sheets, coils and welded tubing

Your cost efficiency goes up with Armco ZINCGRIP Steel because you can get it in the form and sizes to meet *your* design and production requirements. In sheets and coils, it is available in any decimal thickness within the range of 8 to 30 gage and in widths up to 60 inches. Armco ZINCGRIP Tubing extends the advantages of this special steel to tubular parts. It is available in standard and special shapes in sizes equivalent to 3/8 to 3 inches OD.

Galvanized Steel

ARMCO STEEL

ARMCO

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

PY7

Morganite

—solves this difficult sealing problem in

GUIDED MISSILES!

Morganite PY7 Seals provide high reliability in this missile application where premium performance is essential due to severe environmental conditions. Combustion gases at 900°F are on one side, oil at low temperature on the other. Speed is 3600 R.P.M., face load 20 lbs. and mating surface is stainless steel.

Specify Morganite for all seal requirements. Ask Morganite engineers for a recommendation on your specific applications. Morganite seals assure longer life in the presence of grease, searching liquids, corrosives, high pressures and high temperatures. Call or write for complete data, today — please address inquiries on company letterhead.

FOR OVER HALF A CENTURY...

Morganite INCORPORATED

TRADE MARK

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts — Distributors of 99.7% Pure Al_2O_3 Tubes, Crucibles and Crusilite Electric Heating Elements.

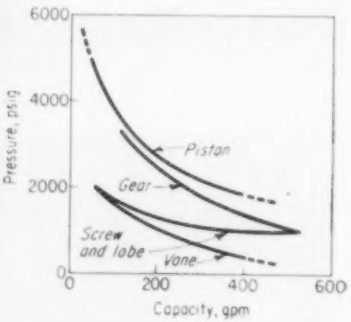
3306 48th Avenue, Long Island City 1, New York

In Canada: Morganite Canada Ltd., Toronto

READER TO EDITOR

Correction:

The pressure-flow curve for gear pumps ("Selection of Positive-displacement Pumps," June 6 issue, p 51; and p 10 of reprinted version) should not extend to



5000 psi as shown, but only to 3000 psi, (corrected chart herewith). Example 4 on same page should be corrected to read: "Flow of 50 gpm at 3000 psi."

Power-weight ratio for vane pump, listed as 0.26 in "Capabilities," p 50, is too low. There are mobile-type vane pumps that deliver as much as 3.0 hp per lb. However, for nonmobile and nonaircraft vane pumps, the 0.26 hp/lb value is reasonably representative. Values for other pump types are correct, based on standard industrial applications.

Relative speed capability of piston pump (table at top of p 50) should have been first in list instead of third. Although there are some gear and vane types faster than some piston types, fastest available pump is piston type—5000 rpm. —Ed

Aluminum in Cars Not New

To the Editor:

Aluminum in auto parts is far more of an on-again, off-again, proposition than your two paragraphs on page 3 (Oct 10 issue) would indicate.

Note that: In 1913, Buick used aluminum in its crankcase, transmission housing and, I believe, the manifold. In 1914, Ford used aluminum intake in the hood, intake manifold, and transmission covers. In the Twenties, aluminum crankcases were usual for V-8's, also into the Thirties. There were some bodies of aluminum. Ford also fooled around with die-cast aluminum heads in the Thirties.

The big question is, will aluminum products for engine and transmission parts now become a permanent feature?

—Roger Krey
RCA Eleetion Tube Div
Harrison, N J

Drawing Arcs

To the Editor:

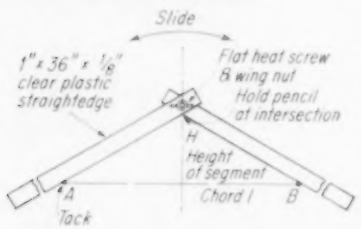
The article, "Centerless Arcs," (Oct 31, p 58) describes methods of laying out

approximately true arcs of varying radii. It brings to mind a gadget I use for drawing arcs of any radius.

1. To construct an arc through 3 points: Set straightedges against tacks and adjust so that third point falls at the inside intersection. Tighten wingnut and place pencil as shown in sketch, and slide the assembly back and forth. The pencil will trace a true circular arc through the 3 points.
2. To construct an arc of given radius through two points: Measure the chord length (from A to B). Using the equation

$$H = R - \sqrt{R^2 - \left(\frac{l}{2}\right)^2}$$

determine the height of segment H and set the intersection of the two straightedges at this height. Proceed as before, drawing the arc.



With 36-in. straightedges an arc of sufficient length for most design purposes can be drawn.

—James D Chapman
Engineering Dept, Hunter Div
Robbins & Myers Inc
Memphis, Tenn

Thanks also to A. J. Tricon, Houston, Texas for suggesting a similar method. —Ed

COMING EVENTS

DECEMBER

13-15 . . . . Institute of Radio Engineers jointly with AIEE & ACM, Eastern Joint Computer Conference, Hotel New Yorker & Manhattan Center, NYC

26-31 . . . . American Association for the Advancement of Science, NYC

JANUARY

9-11 . . . . Institute of Radio Engineers jointly with AIEE, ASQC & EIA, 7th National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia

9-13 . . . . Society of Automotive Engineers, International Congress & Exposition, Cobb Hall, Detroit

16-19 . . . . Instrument Society of America, Winter Conference & Exhibit, St. Louis

For a current listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R32.

DRAFTING TRENDS

In a typical application of the POST Diazo Materials Selector Chart, a draftsman, supervisor and reproduction specialist solve a special print-making problem in short order.

Solve unusual reproduction problems with new Diazo Selector Chart

Keeping up with rapid developments in graphic reproduction and communication techniques is a difficult job these days, even for the experts.

From the engineer's and draftsman's point of view, it's largely a matter of sorting out the specific information which helps him do a better job.

The new Post Diazo Materials Selector Chart does just that—provides a condensed, tabular reference piece that helps you anticipate the ideal diazotype prints for various needs before they occur. This convenient chart gives brief information on sensitized papers, intermediates and specialties in terse "what, when, why and where" style.

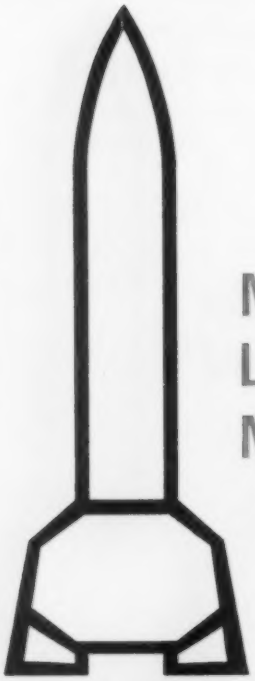
If you're concerned, for instance, with print distribution to different departments, units or groups, then prints on a variety of colored stocks might be the answer.

Increasing print production from diazo equipment with a lower-power light source . . . making legible prints from worn old tracings . . . even making copies from an opaque print . . . all can be handled by use of new Post 206M-14, a fast, extra-sensitive whiteprint paper.

Suppose a design conference calls for a poster, actual size, made from a large engineering drawing, rigid enough for display, tough enough for extreme handling and on-the-spot sketches? Post diazo-sensitized cardstock in 32 or 50 lb. weight can turn the trick on standard reproduction equipment, ammonia process or semi-moist. For many more helpful solutions to similar situations, ask for your personal file-size copy, of the Post Selector Chart, available from your Post dealer or Frederick Post Company, 3642 North Avondale Avenue, Chicago 18, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE



MISSILE LAUNCHER MADE MOBILE-LIGHT, TAKEOFF-TOUGH WITH

N-A-XTRA

HIGH-STRENGTH STEEL

A battlefield might be anywhere. Wherever it is, there may be a need for the new 10,000-pound, 36-foot Sperry-Rand U.S. Army Sergeant missile. That's why the launching station on which the missile is assembled, aimed and fired must be light enough to be transported by land, sea or air. Yet it also has to be rugged and strong enough to assure the launcher's availability for subsequent firing.

N-A-XTRA steels meet all the conditions of light weight, high strength and impact resistance. Pound for pound, they're nearly three times stronger than mild carbon steel. They are used, not only in this mobile missile launcher, but in many other defense products and in commercial equipment such as earth-moving vehicles, heavy machinery and pressure vessels.

Fabrication qualities are an N-A-XTRA bonus. Even at extreme subnormal temperatures, they remain tough and readily weldable. Conventional methods—cold forming, gas cutting, shearing and machining—give superior results, too. For further information, write Product Development Department, Great Lakes Steel Corporation, Detroit 29, Michigan.

N-A-XTRA
A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

Quenched and tempered N-A-XTRA, *the best low carbon extra-strength alloy steels you can buy, are available in four levels of minimum yield strength, from 80,000 to 110,000 psi. They are tough at normal and subnormal temperatures and can be readily and reliably welded. Sizes range from ⅛" to 1" thick, up to 72" wide and up to 35' long.*

Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

Great Lakes Steel is a Division of **NATIONAL STEEL CORPORATION**

for efficient liquid heating . . .

VULCAN IMMERSION HEATERS

Vulcan Electric Immersion Heaters are highly efficient because they are immersed directly in the material to be heated. They are ideal for the heating of all types of liquids — water, oil, wax, paraffin, asphalt, tars, etc., in tanks, boilers, urns, kettles, and other containers.

Heaters are available with flange or threaded bushings; bayonet type, side or bottom outlet; copper, steel, stainless, or alloy sheath; single or three phase; readily adaptable to thermostatic control within close tolerances; full range of wattage and voltage ratings; pressures up to 3500 psi.

Write for catalog and prices.

VULCAN

Versatility in Electric Heating

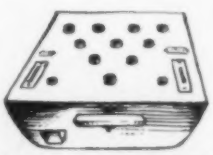
VULCAN ELECTRIC COMPANY
Danvers 18, Mass.

WHY DON'T THEY R&D . . ?

. . . an effective and practical way to keep birds from roosting near airport runways, civic buildings and food-storage facilities. A really good bird repellant would sell itself; should be worth a considerable sum to the company or individual that comes up with the right answer. It's more than just a nuisance problem; aircraft experts believe that a flock of starlings was responsible for last month's Electra crash in Boston. Moreover, bird droppings corrode metals, contaminate grain and other foods in storage facilities, deface buildings and monuments. Many ideas have been tried with more-or-less indifferent success. One company makes a small cannon intended to scare birds away by periodic loud explosions. Another offers a sticky compound that makes roosting uncomfortable for the birds. One expert recommends high-pitched noise radiating from the area to be protected; others suggest setting up loudspeakers some distance from the affected area to lure birds away with recorded mating calls. Other experiments: repellant varnishes, blinking lights, electric fences, drugs, tranquilizers, mechanical devices such as spikes, and scarecrow-like flapping machines. At Boston's Logan Airport they have an obvious but time-consuming scheme: they send a truck down the runway before allowing a plane to take off. We're still waiting for a simple and effective method. E E REED

. . . a vacuum-flexed windshield-wiper blade. A cavity inside the rubber blade would change the blade's shape and stiffness depending on the amount of vacuum applied. The blade could be shaped so that with a strong vacuum it would have a stiff, ice-scraping edge; without the vacuum it would curve inward to form a soft, pliant, surface-hugging squeege for rain and moisture. In addition, the intake bleed hole might be connected to a tube so that it would draw in warm, engine air to keep the blade free of frost and ice. —R MARIE

. . . an electric wrench for plumbers similar to the air drivers and nut runners used in industrial assembly plants (to tighten wheel nuts and head nuts on automobiles, for example). The plumber's wrench would do its work with the jaws of an ordinary pipe wrench but have a built-in solenoid hammer. Powered from the 110-v lines, the solenoid would produce a series of rapid, high-g, angular blows to help loosen stubborn joints or to tighten fittings in awkward locations. —I BREMA



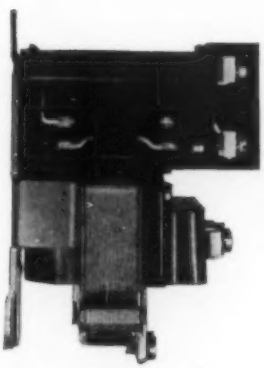
. . . an adapter for automatic pin-setting machines that would permit the bowler to practice difficult shots. A set of pushbuttons at the bowler's end of the alley would allow him to cloose any combination of pins and a repeat switch would allow him to repeat the combination as many times as he wished. The machine could be coin-operated and the bowler would pay on a time basis rather than by the game. —W E PATTERSON

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

How a General Electric CR2810 machine tool relay had . . .

20 MILLION CHANCES TO FAIL

BUT DIDN'T



MORE THAN 20 MILLION TIMES a large automotive body stamping company challenged the General Electric CR2810 machine tool relay to "make" and "break."

It was part of an accelerated life test conducted recently in their own plant to find the most reliable machine tool relay for their continuous production line.

Long after all competitive relays tested had failed, the contacts in the G-E relay were still "making" and "breaking" with continuous reliability. Why? Greater fidelity—made possible by the smooth "wipe and roll" action of the General Electric relay contacts.

OTHER ORIGINAL EQUIPMENT MANUFACTURERS as well as users have proved to themselves the reliability of General Electric relays. For example, after one year's experience with G-E relays, a manufacturer of packaging machinery cut his purchases almost in half. His explanation: "Before I bought General Electric relays, 50 per cent of my purchases were used to replace relays under my maintenance contract." He saved inventory investment and stocking costs. You can too.

Extra reliability is one of the "measurable advantages" of G-E machine tool relays that builds customer acceptance for your products. Add to this the ease of mounting and wiring, the compact design, and the circuit flexibility of G-E relays, and you have a value that can't be matched.

Why not test them yourself? Call your G-E sales engineer at your nearby G-E apparatus sales office. Ask for bulletin GEA-7021. General Electric Company, Schenectady 5, N. Y.

811-13

You get **MEASURABLE ADVANTAGES**
with General Electric Control

Progress Is Our Most Important Product

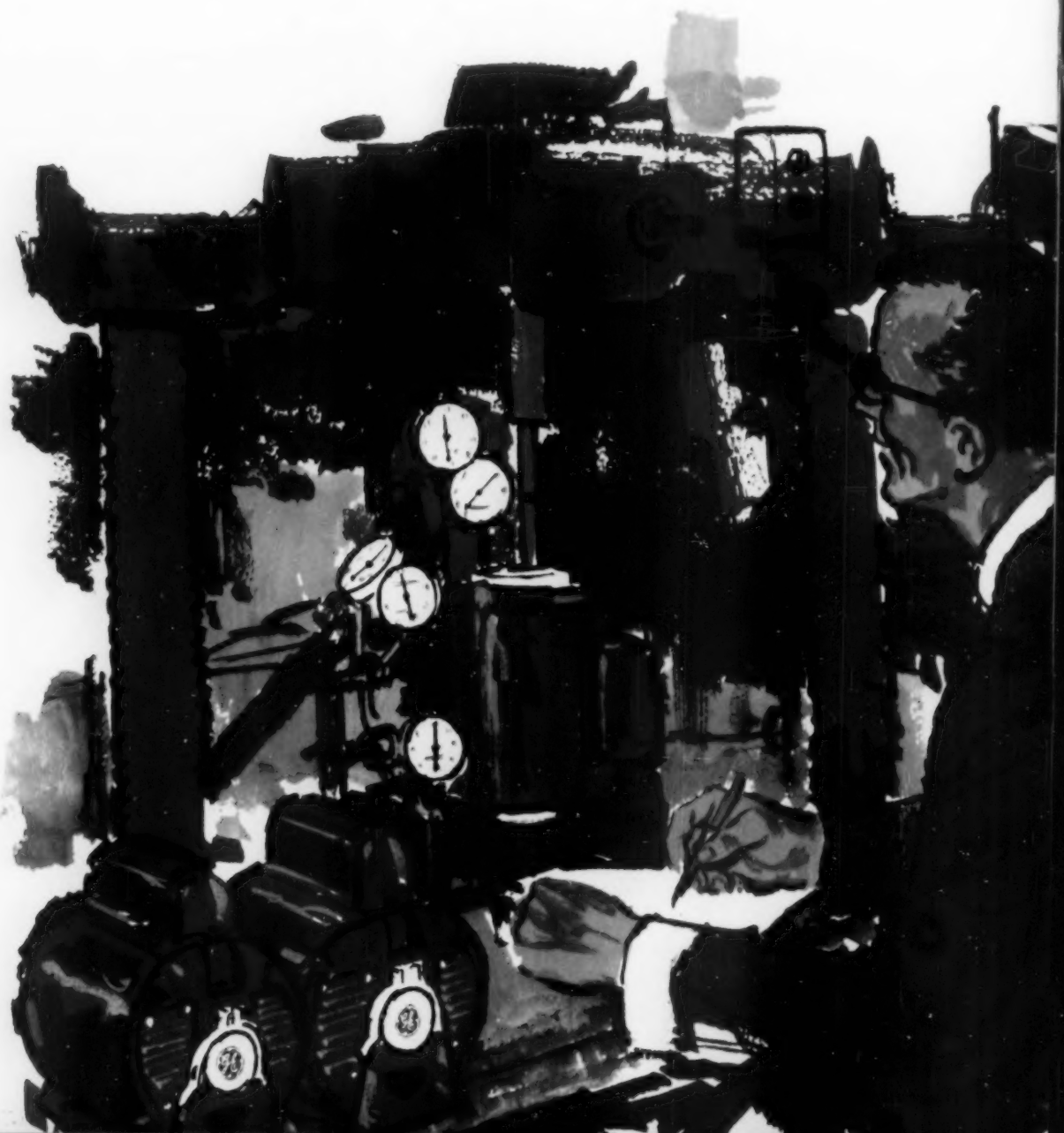
GENERAL ELECTRIC

CIRCLE 33 ON READER SERVICE CARD

You get MORE THAN A MOTOR with General Electric's

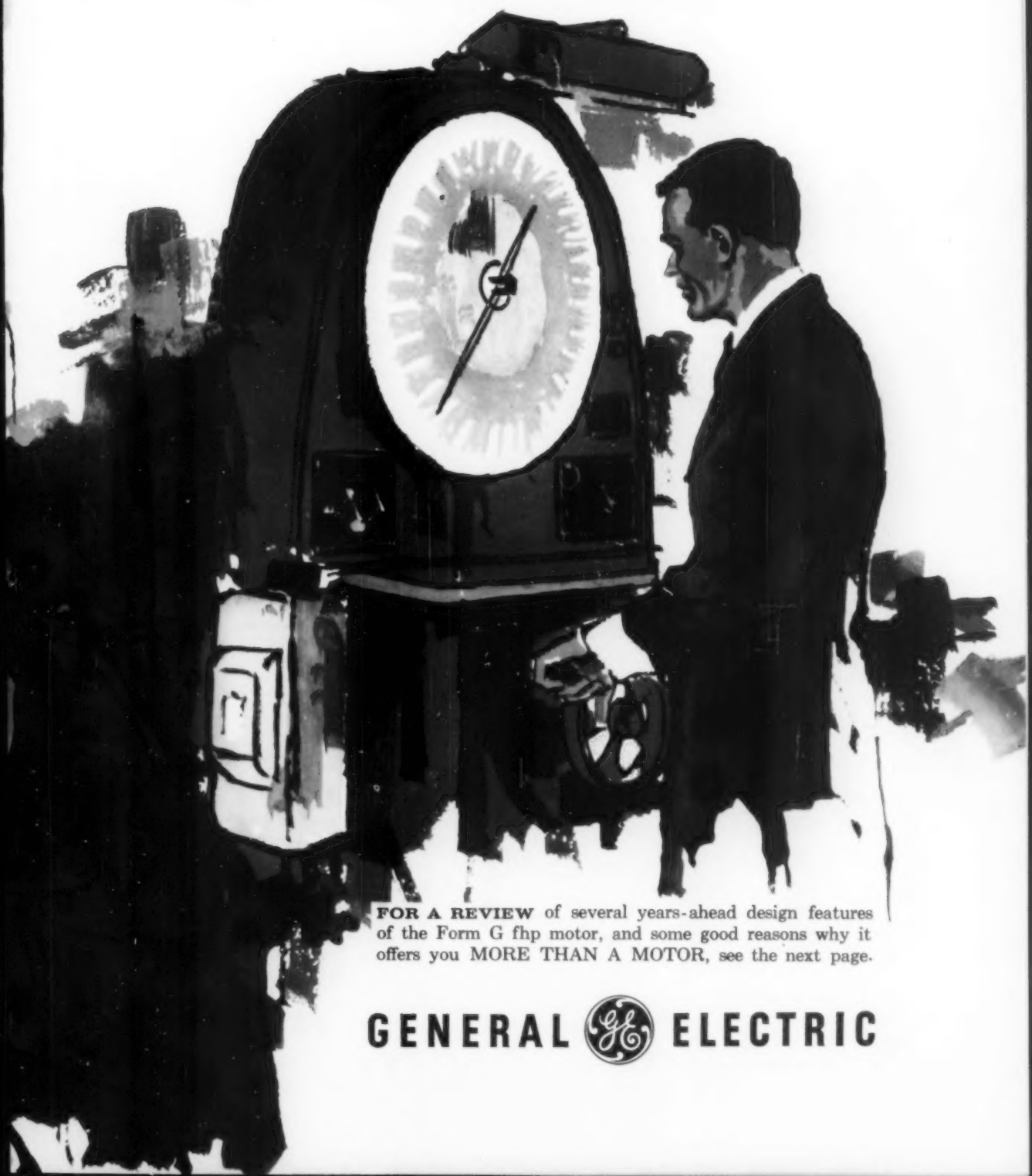
Years-Ahead

Form G leadership among fhp motors isn't accidental. We work hard at it, constantly improving, constantly innovating. We've found it's the best way to help our customers keep ahead of the changing demands in their industries. It's good business on our part. It's good business on your part too . . . to make sure you get the advantages a years-ahead motor can offer your product.



Form G...for example...

Design Leadership



FOR A REVIEW of several years-ahead design features of the Form G fhp motor, and some good reasons why it offers you MORE THAN A MOTOR, see the next page.

GENERAL ELECTRIC

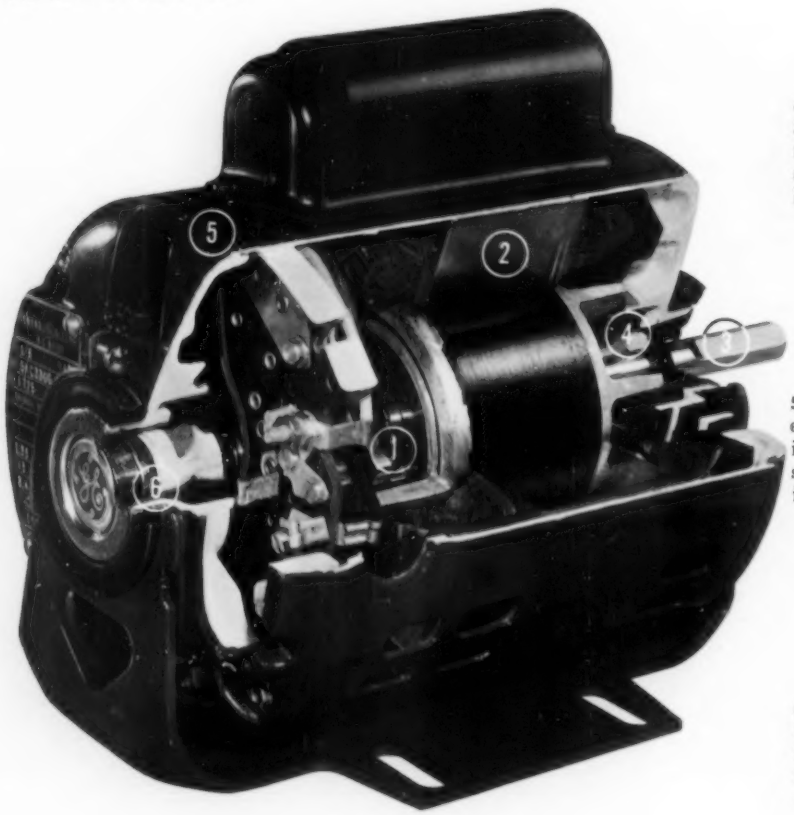
These years-ahead Form G motor features mean long life, reliable performance

1. QUIET SWITCH—specially-designed composition washer in Form G motors cushions start-stop click; maintains positive snap-action; has been tested to last 3,500,000 operations.

2. LONG-LIFE STATOR—heavy-duty stator bonding dip and Mylar* insulation protect against damage caused by heat, stress, moisture. Stator clamps provide additional rigidity.

3. RUST-RESISTANT SHAFT—special gunmetal-like treatment of motor shaft resists rust and corrosion, simplifies product service. Fans, pulleys, and couplings are easy to remove.

*Reg. Trademark of Du Pont Co.



4. LONG-LIFE LUBRICATION—Over 50% more oil than in old-design motors and an efficient oil retention system contribute to motor's doubled lubrication life; cut maintenance.

5. ACCURATE ALIGNMENT—disk-type end shield, heavily ribbed for rigidity, places rabbet and bearing in same plane, provides accurate bearing alignment, long motor life.

6. THRUST PROTECTION—interlocking washer assembly withstands normal thrust from any direction, regardless of motor angle; also acts as an oil seal for long motor life.

Only General Electric Form Gs give you MORE THAN A MOTOR

1. YEARS-AHEAD DESIGN LEADERSHIP—consistent leadership by G.E. keeps Form G customers "out front".

2. EASE OF ASSEMBLY—Form G motors provide assembly-line savings in time and money.

3. EXPERT APPLICATION AID—G-E engineers are always available to help solve unusual motor applications.

4. ON-TIME DELIVERY—multi-plant facilities assure you reliable, prompt delivery of the exact motors you need.

5. VERSATILITY PERSONIFIED—a Form G motor can meet almost any design requirement.

6. FAST, LOCAL SERVICE—a nationwide network of G-E Electric Motor Service Stations means service is always close at hand.

7. QUALITY CONTROL—*every* Form G motor is thoroughly tested at all stages of production to assure you long, dependable performance.

Make sure you get MORE THAN A MOTOR when you select fhp drives for your product . . . choose General Electric Form G motors, available in NEMA 48 and 56 frames. For more information contact your nearby General Electric Apparatus Sales Office or write Section 702-108, General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC

ELECTRONICS.... HYDRAULICS.... HEAT TRANSFER.... LUBRICATION

NUCLEONICS.... SONICS.... COOLANTS.... DIELECTRICS:

Monsanto Specialized Fluids and new FluiDesign Service can help you benefit from

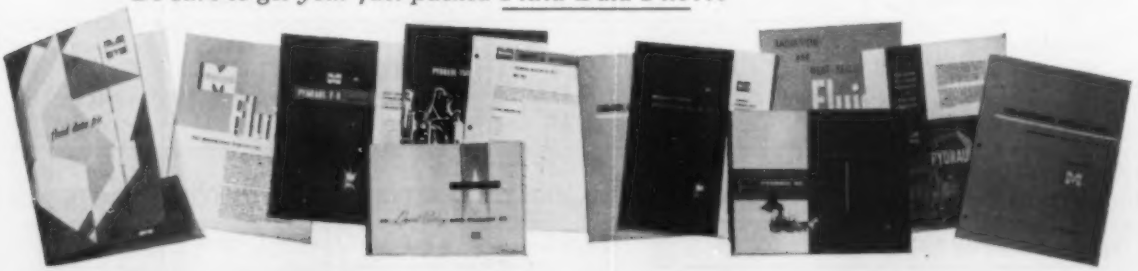
A RENAISSANCE IN ENGINEERING DESIGNS

Conventional fluids (water, oil) impose well-known restrictions on engineering designs. Heat, radiation, fire hazard, shear, electrical requirements, extreme pressure, friction—all cause problems—limit you in design flexibility, in imaginative thinking, in new ideas.

Monsanto's specialized synthetic fluids—chemically tailored to minimize many design restrictions in power transmission, lubrication, heat transfer, insulation, cooling—make new and improved designs practical. Spawned by advances in specialized fluid properties and broadening of fluid functions—a renaissance in engineering concepts is starting now. These specialized fluids open new design opportunities for your exploration.

Monsanto's new FluiDesign Service—established to help you meet your needs best from the capabilities of some thirty specialized fluids—can give you valuable guidance at the outset of your design exploration and engineering planning. For example, the next two pages provide you with the FluiDesign Service Report, "Heat-Stable Fluids for *Critical* Thermal Conditions." Among the thermally stable and radiation-resistant fluids described, one or more may allow you to engineer your next design for unequaled efficiency.

Be sure to get your fact-packed Fluid Data File...



←CIRCLE 36 ON READER SERVICE CARD

CIRCLE 37 ON READER SERVICE CARD

From Monsanto FluiDesign Service . . .

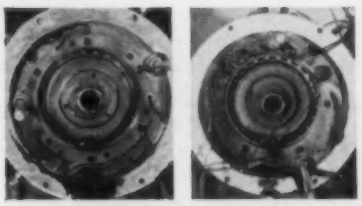
HEAT-STABLE FLUIDS FOR CRITICAL THERMAL CONDITIONS

Rapid evaporation, variable viscosity, foaming, cavitation, and "gunking up" at high temperatures are shortcomings of many common functional fluids. They are symptoms of thermal instability that bedevils operation of equipment.

Monsanto has developed a whole series of heat-stable synthetic fluids that eliminate many restrictions on new equipment design—*for applications that demand optimum thermal stability*. These chemically synthesized fluids include silicate esters, chlorinated polyphenyls, polyphenyls, and polyphenyl ethers. Some perform at freezing temperatures below *minus* 65° F. Others withstand continuous scorching heat above 800° F. Many are fire-resistant, radiation-resistant, noncorrosive. They give long, low-maintenance service as heat transferants, as lubricants, as hydraulic fluids, as dielectrics in high-temperature applications.

Monsanto Fluid	OS-59	Coolanol 35	Coolanol 45	Aroclor 1221	Aroclor 1232	
Properties						
Max. bulk temp., °F. long term	500	400	400	600	600	
Radiation resistant . . .	No	No	No	No	No	
Thermal conductivity Btu/hr./ft.²/ft./°F. . .	0.077	0.079	0.080	0.067	0.063	
Specific heat, @ 25°C.. .	0.45	0.45	0.45	0.33	0.31	
Boiling point, °F. @ 760 mm. Hg	> 700	> 600	> 700	527	554	
Flash point, °F. Cleveland Open Cup .	370	370	370	295	308	
Fire point, °F. Cleveland Open Cup .	435	430	430	349	460	
Auto-ignition temp., °F. .	. . .	655	700	> 1000	> 1100	
Viscosity, cs. @ –65°F. . . . . @ 100°F. . . . . @ 210°F.	1380 6.8 2.2	934 6.5 2.2	2400 12.2 3.95	. . . 4.6 < 1.8	. . . 6.9 < 1.8	
Coefficient of thermal expansion, per °F. . .	0.00046	0.00047	0.00048	0.00039	0.00040	
Specific gravity @25°/25°C.	0.88	0.89	0.89	1.18	1.26	

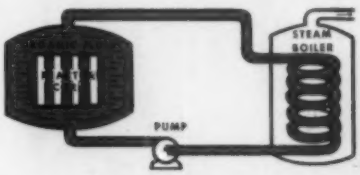
Monsanto offers a family of unique new fluids—*polyphenyl ethers*—that outperform all other known lubricants and hydraulic fluids in high-temperature operations. Their *useful* temperature range exceeds other thermally stable fluids by 100° to 400° F. The polyphenyl ethers not only match the lubricity and viscosity indices of other good lubricants, but also possess superior hydrolytic stability.



Photos courtesy of Pratt & Whitney Aircraft

Test rig parts for evaluating properties of jet engine lubricants show how a polyphenyl ether (left) leaves the rig parts clean, free of deposits, and with no evidence of wear. Photo at right shows deposits and general condition of parts using one of the best synthetic lubricants available prior to development of polyphenyl ethers. Both tests were run at a bearing temperature of 500° F. for 100 hours at a speed of 10,000 rpm.

Some Monsanto fluids are so radiation-resistant and thermally stable that they are used in the torturous environment of the nuclear reactor. Under an A.E.C. contract to develop low-cost electricity from nuclear power, Atomics International designed and built an experimental reactor at Arco, Idaho . . . using Monsanto terphenyl compounds as the coolant-moderator and heat-transfer agent. Nearly three



years of testing indicate that these stable Monsanto fluids can successfully and economically transfer the tremendous heat of the "nuclear furnace" to steam generators.

Check the fluids described below for application in equipment you are using or developing. Monsanto can supply you with a thermally stable fluid to solve virtually any critical problem of high heat or radiation. By advance planning with Monsanto FluiDesign Service, it is possible to "chemically tailor" a stable synthetic fluid to your precise needs.

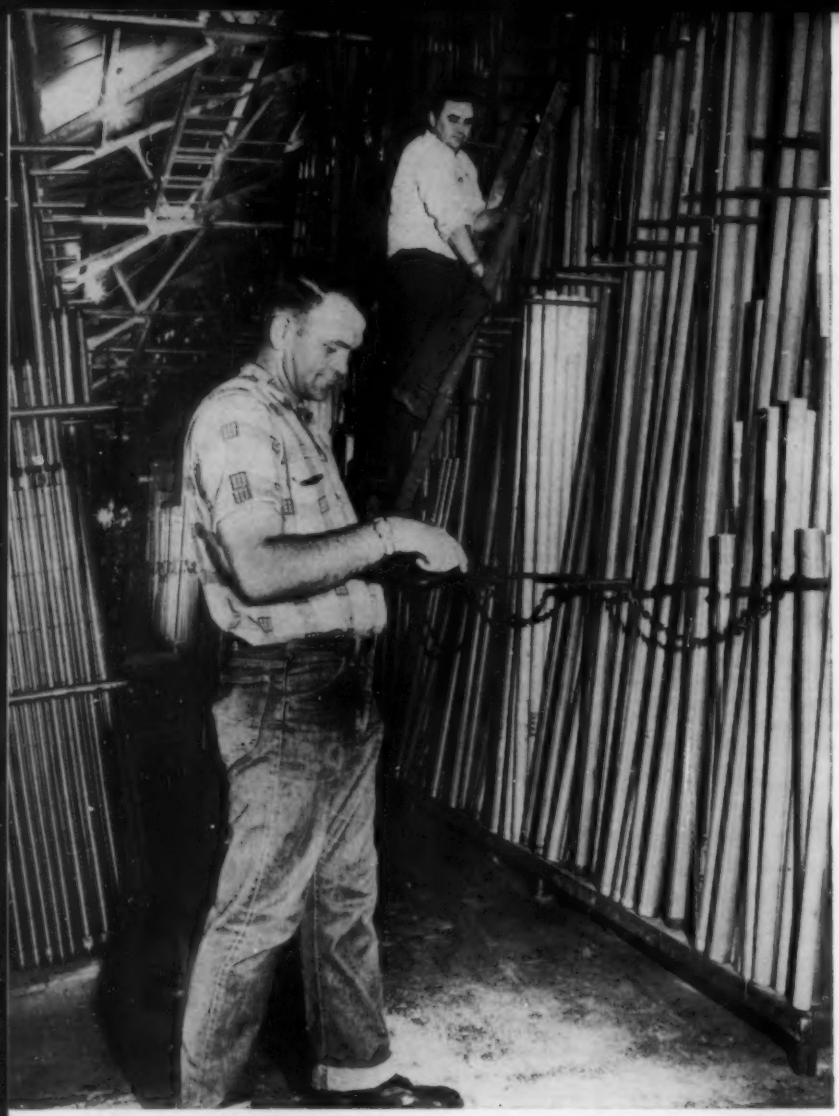
Samples of the fluids shown will be sent to you for evaluation on request. Please specify the particular fluid that interests you and state the nature of the application, so that pertinent details can be sent to you. For further information on available fluids, request a copy of FluiDesign Service's FLUID DATA FILE. Simply write on your company letterhead.

HB-40, Aroclor, Coolanol, Santowax: Monsanto T.M.s, Reg. U. S. Pat. Off.

Monsanto

Monsanto Chemical Company
Organic Chemicals Division
FluiDesign Service, Dept. 2765-B
St. Louis 66 Missouri

	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	OS-124 (polyphenyl ether)	HB-40	Santowax R
	600	600	600	600	800	800	> 750
	No	No	No	No	Yes	Yes	Yes
	0.058	0.057	0.054	0.051	0.077	0.072	0.063
	0.29	0.27	0.26	0.26	0.34	0.45	0.50
	617	644	689	725	982	683	687
	360	379	None	None	550	345	375
	> 610	> 640	> 662	> 698	660	385	460
	> 1200	> 1200	> 1200	> 1200	1135	> 1000	> 1000
	. . . 17.2 2.5	. . . 45.3 3.2	. . . 46.4 6.14	 75	. . . 363 13.2	. . . 29 3.9	. . . .
	0.00038	0.00039	0.00037	0.00037	0.00033	0.00041	0.00052
	1.38	1.45	1.54	1.62	1.204	1.002	0.955



SEAMLESS STEEL BARRELS and other pump components of Harbison-Fischer's rod and tubing displacement pumps show great size range required to bring oil to the surface. Pumps vary on I. D. from ¾ inch to 5¾ inches; from 3 to 42 feet in length. Harbison-Fischer counts on commercial quality Pittsburgh Seamless Mechanical Tubing to get a 4 to 6 micro-inch I. D. finish with minimum clean-up expense.

Pittsburgh Seamless Tubes Give a Lift...

WHEN OIL MEN MAN THE PUMPS

When the gusher quits gushing and the oil flow slows to a trickle, it's time for oil men to man the pumps.

Pittsburgh Steel Company helps give them the lift they need with seamless mechanical tubing for sub-surface displacement pumps made by Harbison-Fischer Manufacturing Company of Fort Worth, Texas.

Nine of every ten producing wells must be pumped—and most depend on slender, precision-made rod and tubing pumps for efficient oil production. Harbison-Fischer has supplied them to the oil industry for more than 25 years—"The Best Pumps in the Oil Patch."

Among its eight types and wide range of sizes, there's a Harbison-Fischer pump to match every lifting job and well condition, whether it be depth, heat, pressure, corrosion or abrasion.

Pittsburgh Seamless Mechanical Tubing forms the pump barrel that contains plungers and valves. Besides destructive conditions below surface, barrels often must bear the weight (5 to 6,000 psi) of a fluid column of oil 10,000 feet or more deep.

● **Tight Specs**—To meet rigid API standards as well as its own manufacturing needs, Harbison-Fischer requires mechanical tubing with exact chemical and physical properties, and close tolerance I. D. and wall dimensions.

It demands tubing that is exceptionally straight, free of seams, laps and pits; made of steel that is machinable, and—in the high carbon range—fine grained and hardenable.

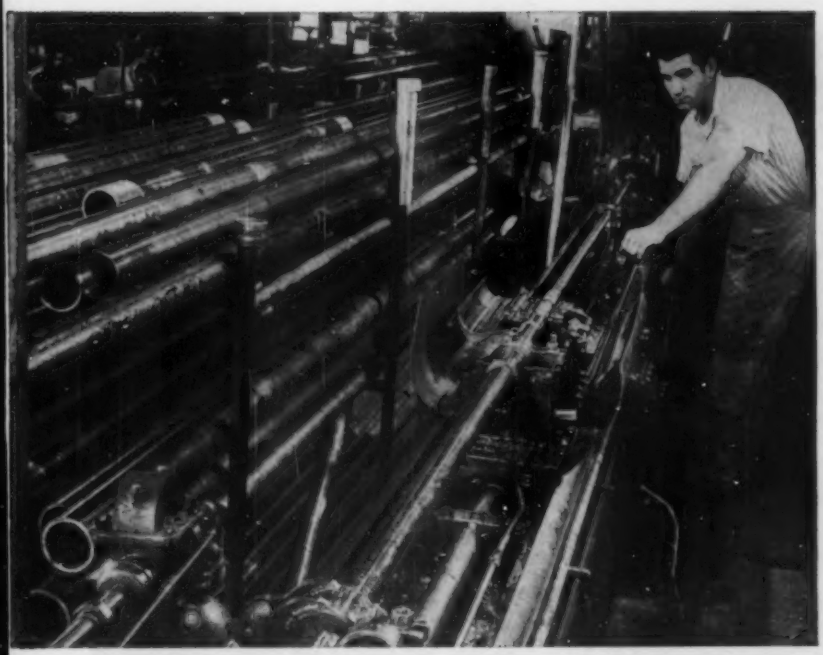
Pittsburgh Steel answers these requirements with mechanical tubing in C-1015 and C-1040 grades in commercial quality to help Harbison-Fischer hold processing to a minimum.

● **Fine I. D. Surface**—In production, Harbison-Fischer wants minimum stock removal to obtain a mirror I. D. finish and extreme straightness.

On its dozen long-stroke hydraulic hones, H-F holds the I. D. stock removal to a few thousandths of an inch. Says Harbison-Fischer:

"The honed I. D. must be entirely free of pits. We want a four to six micro-finish. So you can see why the tubing's I. D. mill finish is important."

After threading and honing, every barrel is re-straightened to a tolerance of .015 TIR (total indicator



STRAIGHTNESS, CLOSE TOLERANCE wall thickness and absence of seams, laps and pits in Pittsburgh Seamless Tubing mean fast, easy clean-up on horizontal hones. Minimum stock removal in honing tube's inner surface results in a mirror finish. Six-foot tube being set up here will become working barrel of two-inch tubing pump.

HONED TUBE GETS RIGID INSPECTION. Inspector uses I. D. micrometer to make certain barrel of 3-inch tubing pump stays within tolerance limits of —.0000/ +.0015 inch.

PRODUCTION PERSONNEL check wide variety of tubing used by Harbison-Fischer to produce "Best Pumps in the Oil Patch" for world-wide market.

reading) to overcome distortion caused by working of the tubing.

For installations where hard pumping and hard wear are factors, Harbison-Fischer heat-treats high carbon barrel tubing by an exclusive electronic process. The process penetrates the I. D. a predetermined depth to produce exceptional wearing quality, while permitting the O. D. to remain ductile and shock resistant.

Applications such as Harbison-Fischer's are typical of the uses to which Pittsburgh Seamless Tubing is put. There are thousands of them.

If you manufacture cylindrical products or parts requiring close tolerance, smooth surface or specific physical properties, Pittsburgh Seamless Mechanical Tubing can save you time and processing costs. Contact one of the district offices or distributors listed at the right. A Pittsburgh Steel representative will show you how.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel Corporation
San Francisco, California

Earle M. Jorgensen Co.

Kilsby-Tubesupply, Division of
Republic Supply Co.
of California
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.

Solar Steel Corporation
Cleveland, Ohio

Standard Tube Sales Corp.
Brooklyn, New York

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Tubular Service Corp.
Springdale, Pennsylvania

Ward Steel Co.
Boston, Massachusetts

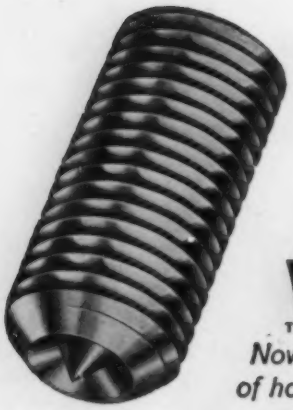
Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta, Chicago, Cleveland, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio



Another New Fastener Idea From Parker-Kalon

The New PARKER-KALON **W-POINT** Socket Set Screw

T.M. U.S. PATENT NO. 2,907,240

Now you can get the highest degree of holding power ever attained!

30% more back-out torque 50% more resistance to vibration 50% more resistance to rotary slippage

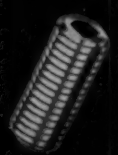
Like many important advances in technology, the Parker-Kalon W-Point concept is simple and straightforward. In use, its superior performance and holding power will be demonstrated to your own satisfaction. Available from P-K distributors at no increase in cost.

A COMPLETE LINE OF SOCKET SCREWS TO MEET EVERY REQUIREMENT!

SOCKET HEAD CAP SCREWS

Heads are of uniform diameter. Threads Class 3A tolerance. Available in standard sizes from #0 to 1½" diameter in alloy steel and from #0 to ¾" diameter in stainless steel. Available in 1936 and new 1960 "Pyre-Lode" Series.

SOCKET SET SCREWS



Precision Class 3A threads, standard in Cup Point from #0 to 1" and in Flat, Oval, Cone and Half-Dog Points from #4 to ¾". Cup Point also available in stainless steel.

SHOULDER SCREWS

Threads Class 3A tolerance. Heads are concentric with body for uniform, accurate assembly. Available in standard sizes from ¼" to ¾" diameter.

FLAT HEAD SOCKET CAP SCREWS

Seats flush when countersunk. Heads have uniform 82° angle. Threads Class 3A tolerance. Special alloy steel, heat treated. Available in standard sizes from #4 to ¾".

BUTTON HEAD SOCKET CAP SCREWS

Heat treated alloy steel. Accurate hex sockets make for non-slip driving, prevent mutilated heads. Threads Class 3A tolerance. Standard sizes from #4 to ¾".

SOCKET SEMS

P-K is the only fastener manufacturer to provide socket Sems, to meet your needs for precision-made socket head cap screws with split ring washers.

HEX KEYS

Made of special analysis alloy steel, scientifically engineered. Heat treated for optimum physical characteristics. Made to close tolerances.

DOWEL PINS

SOCKET PIPE PLUGS

Now you can get all of these famous P-K® quality socket screws with or without

the vibration-resistant **LONG-LOK® INSERT!**

Look at that groove! It's P-K's secret weapon against vibration. Filled with Polycap nylon-type polymer, it solves a thousand and one problems where vibration is present . . . where adjustment is required . . . where reuse is a factor, over a wide temperature range.

- *Provides higher resistance to shock*
- *Higher percentage of reusability*
- *Superior thread engagement and locking force*
- *Eliminates need for lock washers, safety wires*
- *The Long-Lok insert is available on P-K Socket Head Cap Screws, Set Screws, Flat Heads, Button Heads, Shoulder Screws and Pipe Plugs.*

PARKER-KALON

FASTENERS

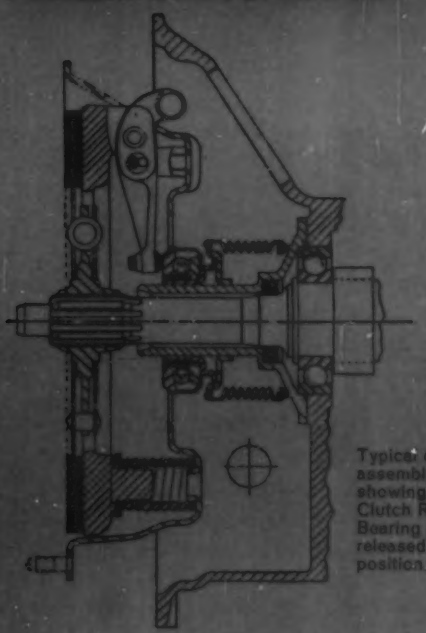
Parker-Kalon Division, General American Transportation Corporation, Clifton, New Jersey. Offices and Warehouses in Chicago and Los Angeles.

KEEP AMERICAN INDUSTRY AT WORK . . . BUY P-K . . . MADE IN U.S.A.

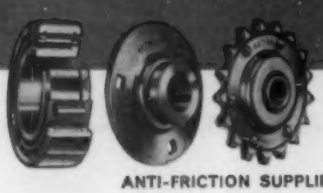
Aetna
CLUTCH RELEASE BEARINGS

1,500,000 DE-CLUTCHINGS
Prove Longer Service Life—Silent Operation

Under every type of operating condition, Aetna Clutch Release Bearings have proved their dependability. Actual abusive breakdown tests of up to 1,500,000 de-clutchings have established Aetna's unmatched superiority in life expectancy; smooth, silent, trouble-free operation; and greater lubricant retention ability. It's no wonder then that over 50% of America's major producers of mobile vehicles specify Aetna Clutch Release Bearings as standard equipment. For complete information, call your local Aetna representative listed in your classified telephone directory, or write for General Catalog and Engineering Manual.



Typical clutch assembly showing Aetna Clutch Release Bearing in released position.



AETNA BALL AND ROLLER BEARING COMPANY
DIVISION OF PARKERSBURG-AETNA CORPORATION

4600 SCHUBERT AVE.
CHICAGO 39, ILL.

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

DODGE HAS MORE PROVED BEARINGS THAN YOU HAVE BEARING PROBLEMS!

It pays to buy from a line of stock bearings—bearings that have been proved in thousands of installations similar to yours. You benefit by getting known dependability; and you get the important savings of high quality at production price.

PIN-POINT SELECTIVITY

Dodge has supplied mounted bearings to industry for over three-quarters of a century. Dodge bearings have always kept pace with improved production practices. Each new condition of service has been met by Dodge as it has arisen, with the result that the Dodge line contains mounted bearings to meet almost every service requirement with pin-point accuracy.

High load, high speed, excessive dust, moisture, corrosion, high or low temperatures, continuous operation—you name it!—such conditions and their combinations are met every day with Dodge bearings.

BROAD LINE—WIDELY DISTRIBUTED

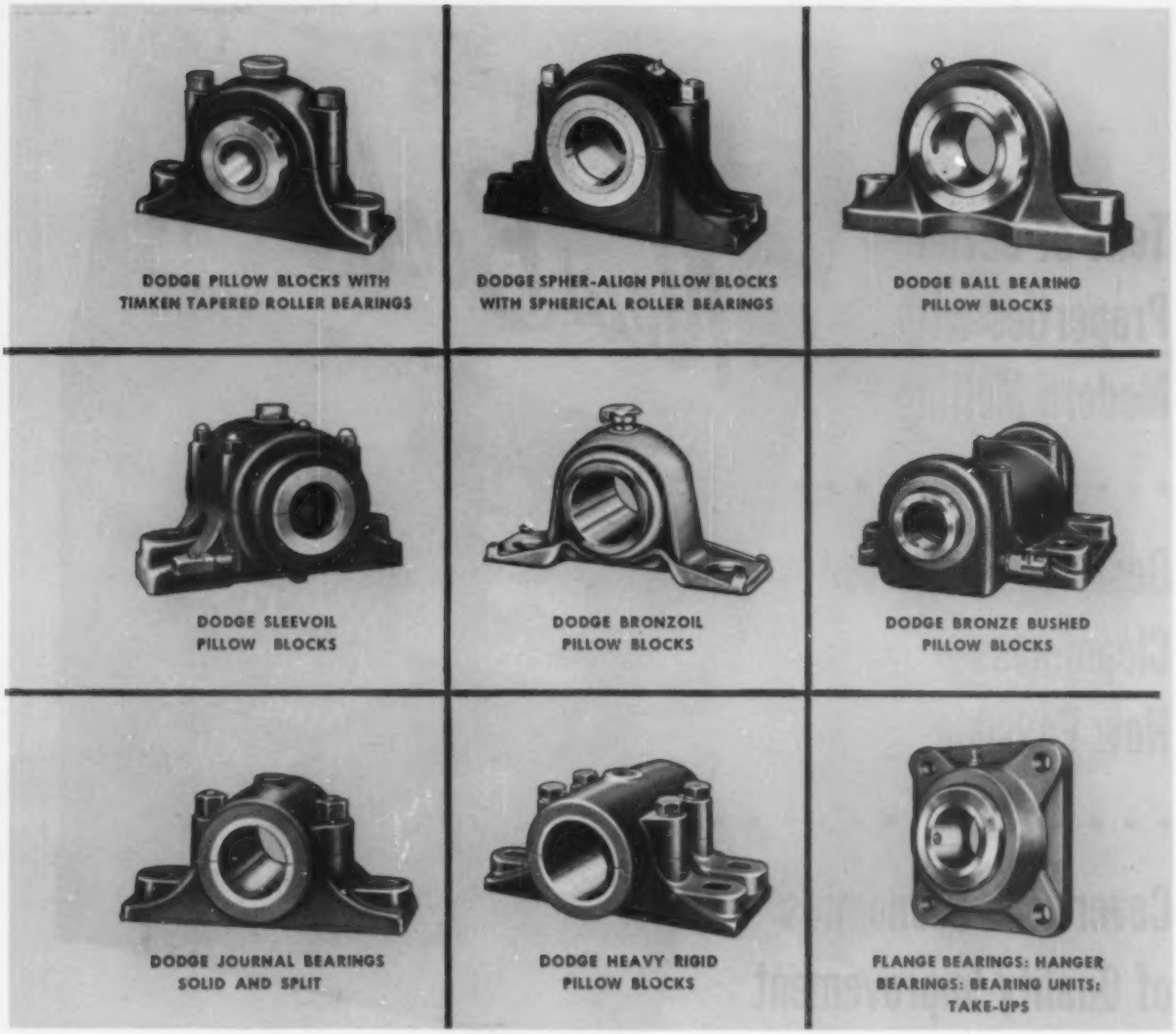
In the great variety of mounted bearings developed by Dodge, you will most likely find the precise unit to fit your requirements ideally—without paying for features you do not need. And if your requirements call for several types of bearings, there is an advantage in having them of common design, such as Dodge offers.

The Dodge line is probably broader than any other line of mounted bearings in America. And of special importance to machinery manufacturers, it is the most widely distributed line. There is always a Dodge bearing of the right type and size near at hand.

You can check this with your local Dodge Distributor. Ask him—or write us for the Dodge Bearing Bulletin.

In addition to tapered roller, spherical roller and ball bearings, Dodge builds many types of sleeve bearings. Here is the "large and small" of the sleeve type bearings carried in stock—ranging from an 8-in. Sleevoil weighing over 1200 lbs. to a ½-in. solid journal bearing weighing 9 ounces.

DODGE MANUFACTURING CORPORATION, 1200 Union Street, Mishawaka, Indiana


DODGE PILLOW BLOCKS WITH TIMKEN TAPERED ROLLER BEARINGS
DODGE SPHER-ALIGN PILLOW BLOCKS WITH SPHERICAL ROLLER BEARINGS
DODGE BALL BEARING PILLOW BLOCKS
DODGE SLEEVOIL PILLOW BLOCKS
DODGE BRONZOIL PILLOW BLOCKS
DODGE BRONZE BUSHED PILLOW BLOCKS
DODGE JOURNAL BEARINGS SOLID AND SPLIT
DODGE HEAVY RIGID PILLOW BLOCKS
FLANGE BEARINGS: HANGER BEARINGS: BEARING UNITS: TAKE-UPS

● **Dodge Pillow Blocks with Timken Tapered Roller Bearings.** America's quality pillow blocks. Assembled, lubricated, adjusted and sealed at the factory. 5 types for varying needs.

● **Dodge Spher-Align with Spherical Roller Bearings.** Rugged heavy duty, compact, inherently self-aligning. Exclusive Micro-Mount simplifies installation.

● **Dodge Ball Bearing Pillow Blocks.** Deep groove ball bearings with long inner races—high capacity. SL, SC and SCM models for light, normal and medium service respectively.

● **Dodge Sleevoil Pillow Blocks.** Ultra quality . . . extra long life . . . accessibility . . . *quiet*. Plain or water-cooled.

● **Dodge Bronzoil Pillow Blocks.** Efficient, low cost pillow blocks with self-oiling, capillary bronze bushings. Self-aligning. Large oil reservoirs.

● **Dodge Bronze Bushed Pillow Blocks.** Quiet fan and blower pillow blocks with two bronze bushings of high lead content mounted in one cast iron housing.

● **Dodge Journal Bearings — Solid and Split.** True running, dependable. Babbitted bearings with precision machined bores and faces. Finished bases.

● **Dodge Heavy Rigid Pillow Blocks.** Rugged, carefully bored, babbitted pillow blocks for many applications requiring grease lubrication. Finished bases and ends.

● **Bearing Units.** A wide variety—spherical seat, cartridge, flange, hanger, screw conveyor hanger, take-up. Ball, Roller and Sleeve types.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

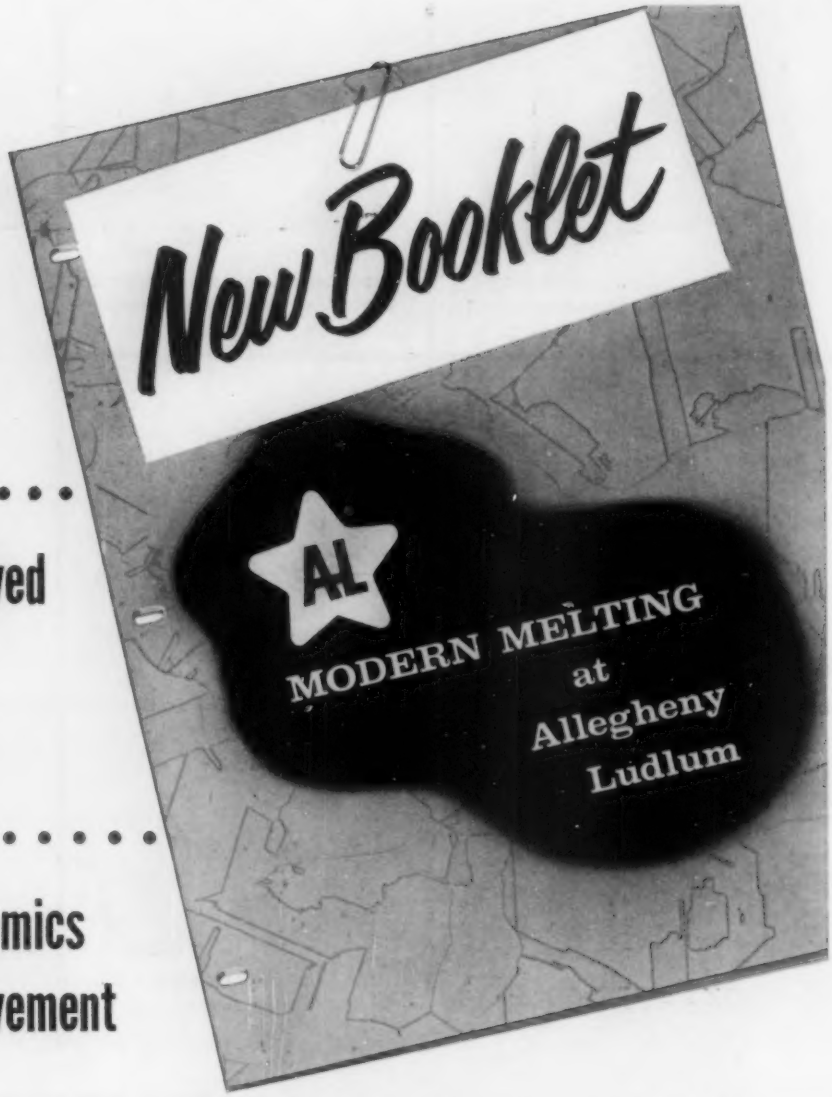
DODGE

of Mishawaka, Ind.

Tells of Better Properties with Modern Melting

Describes Improved Cleanliness Now Possible

Covers the Economics of Quality Improvement



Here is a brand-new technical guide to help you when you need extra physical properties and cleanliness—whether in super alloys or bearing steels, low alloy steels, stainless steels, or tool steels.

This new Allegheny Ludlum booklet explains the advantages of A-L's Special Air Melting and vacuum degassing. Special attention is paid to the consumable electrode vacuum process for making Consutrode® steel alloys, the induction vacuum melting process for Invac materials, and a process combining induction vacuum melting with consumable electrode vacuum remelting for making the Invacutrode steels and alloys used in the most critical applications.

Various uses for each process are listed along with the basic features of each process. Detailed charts present the melting characteristics for each process and compare the gas content, cleanliness, workability, mechanical properties, segregation, and relative cost of alloys produced by the various processes.

If your job involves getting the most out of metals, you will find much useful information in this 20-page booklet, Modern Melting at Allegheny Ludlum. It's packed full of charts and graphs. For your copy ask your A-L representative, or write: ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept.*** PE-12.

ALLEGHENY LUDLUM

PIONEERING on the Horizons of Steel

AL®

8117

Makes products look better . . . and production move faster with fewer rejects

Your product, too, can have the warm, colorful, sales-stimulating look of textured Masland Duran Clad. As an *integral* finish, this vinyl-metal laminate helps you speed production by eliminating painting, spraying, finishing. Also, its textured beauty is unaffected by forming, drilling, crimping, stamping, etc. No new equipment needed. Cleans easily. Mail coupon for samples.

Industrial Products Division

THE MASLAND DURALEATHER CO., Dept. PE, Philadelphia 34, Pa.

Masland Duran Clad on side, top and bottom panels of Portable High Speed Framing Camera by

abtronics inc.

Livermore, California

The Masland Duraleather Co., Dept. PE,
Amber & Willard Sts., Philadelphia 34, Pa.

Please send information and samples of Clad.

Name_____ Title_____

Company_____

Street_____

City_____ Zone_____ State_____

Quick delivery of the Drive you need!

Typical final assembly of A-S Drives from completed sub-assemblies

When you purchase a Square D A-S Drive, you get a complete "package"—including drive motor, operator's station and all controls. You also get these important advantages:

QUICK DELIVERY • Square D's unique method of stocking sub-assemblies means quicker deliveries of packaged drives to meet your requirements.

EASY INSTALLATION • Maintenance manuals are complete in every detail, including step-by-step installation instructions. Moreover, each **A-S Drive** is completely factory-tested and adjusted when shipped — only a few trimming adjustments are needed to put it in operation.

MINIMUM MAINTENANCE • Industrially rated components are used throughout, and extra-sturdy cabinets give lasting protection. Static elements and encapsulated circuits—which are virtually maintenance-free — are utilized wherever possible.

EXTRA SAFETY • Only push buttons with heavy-duty construction and potentiometers with industrial clearances are used in operator's stations, for maximum personnel safety.

WIDE VARIETY AVAILABLE • There's a Square D "package" for *any* adjustable-speed job. You can choose from electronic, magnetic amplifier or motor-generator types — with ratings from 1/20 to 400 hp — and with accuracies to within fractions of 1%.

FIELD APPLICATION HELP • Square D has wide experience in the design and manufacture of adjustable-speed drives, and field specialists are trained to help you in the selection of the proper drive.

Write FOR BULLETIN • *Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin*

SQUARE D COMPANY

wherever electricity is distributed and controlled

stainless steel

No other metal has the strength, beauty and versatile qualities that serve you so well today and promise so much for tomorrow.

There is nothing like stainless steel for HOMES AND HOME PRODUCTS

McLouth Steel Corporation,
Detroit 17, Michigan

Manufacturers of high quality Stainless and Carbon Steels

Look for the **STEELMARK** on the products you buy.

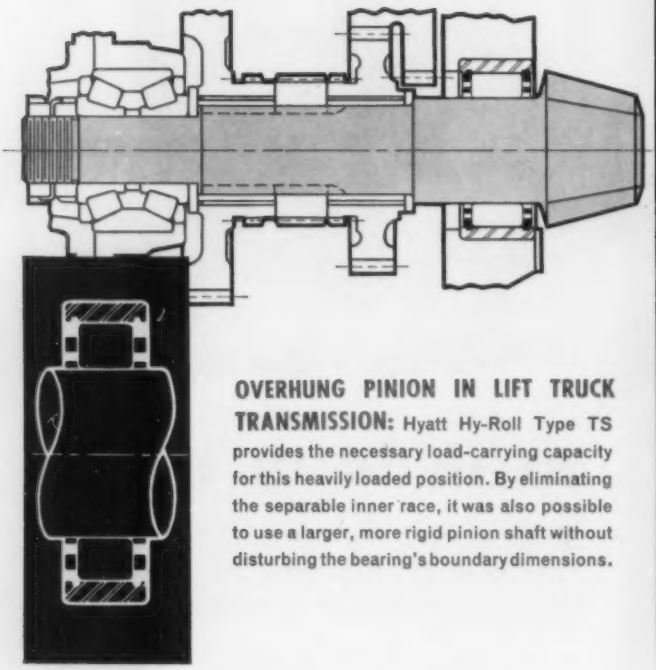
McLOUTH STAINLESS STEEL

CIRCLE 49 ON READER SERVICE CARD

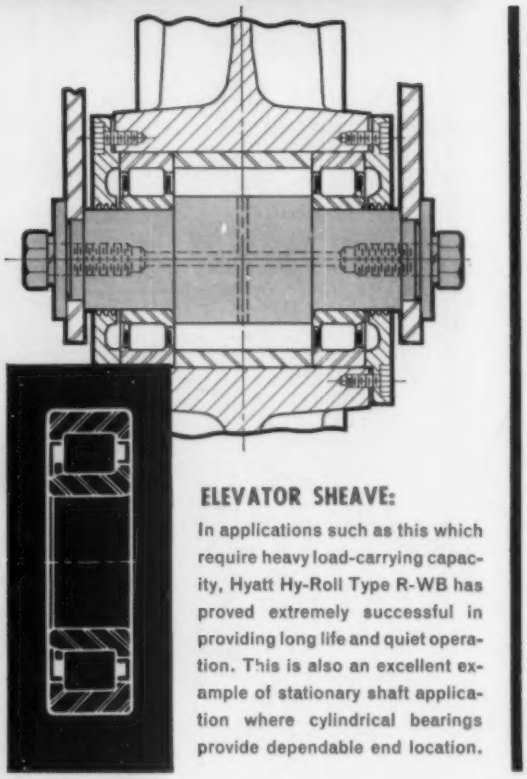
HOW YOU CAN IN LESS HYATT

YOU'LL SOLVE THE DESIGNER'S DILEMMA WHEN YOUR "SPECS" READ HYATT

TYPICAL SPACE-SAVING EXAMPLES!



OVERHUNG PINION IN LIFT TRUCK TRANSMISSION: Hyatt Hy-Roll Type TS provides the necessary load-carrying capacity for this heavily loaded position. By eliminating the separable inner race, it was also possible to use a larger, more rigid pinion shaft without disturbing the bearing's boundary dimensions.



ELEVATOR SHEAVE: In applications such as this which require heavy load-carrying capacity, Hyatt Hy-Roll Type R-WB has proved extremely successful in providing long life and quiet operation. This is also an excellent example of stationary shaft application where cylindrical bearings provide dependable end location.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the bearing surfaces can be brought to suitable hardness and finish.

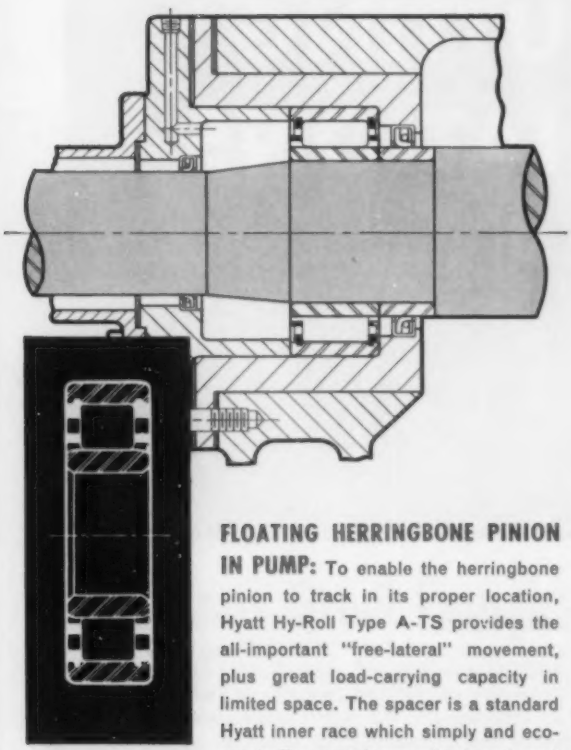
For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt sales engineer.

Hyatt produces 10 major bearing types—four have separable inner races

—four non-separable

—and two have separable outer races.

CARRY MORE LOAD SPACE WITH ROLLER BEARINGS



FLOATING HERRINGBONE PINION IN PUMP: To enable the herringbone pinion to track in its proper location, Hyatt Hy-Roll Type A-TS provides the all-important "free-lateral" movement, plus great load-carrying capacity in limited space. The spacer is a standard Hyatt inner race which simply and economically provides a hardened and ground surface for the seal.

One of the dilemmas facing design engineers these days is the result of two contrary trends in modern machine design. The one trend is towards higher horsepowers which require heavier shafts and impose greater radial loads on bearings. The other trend calls for reduction in envelope and housing dimensions to save space and weight wherever possible. The answer is in bearings which will carry more load in less space, and that means cylindrical roller bearings.

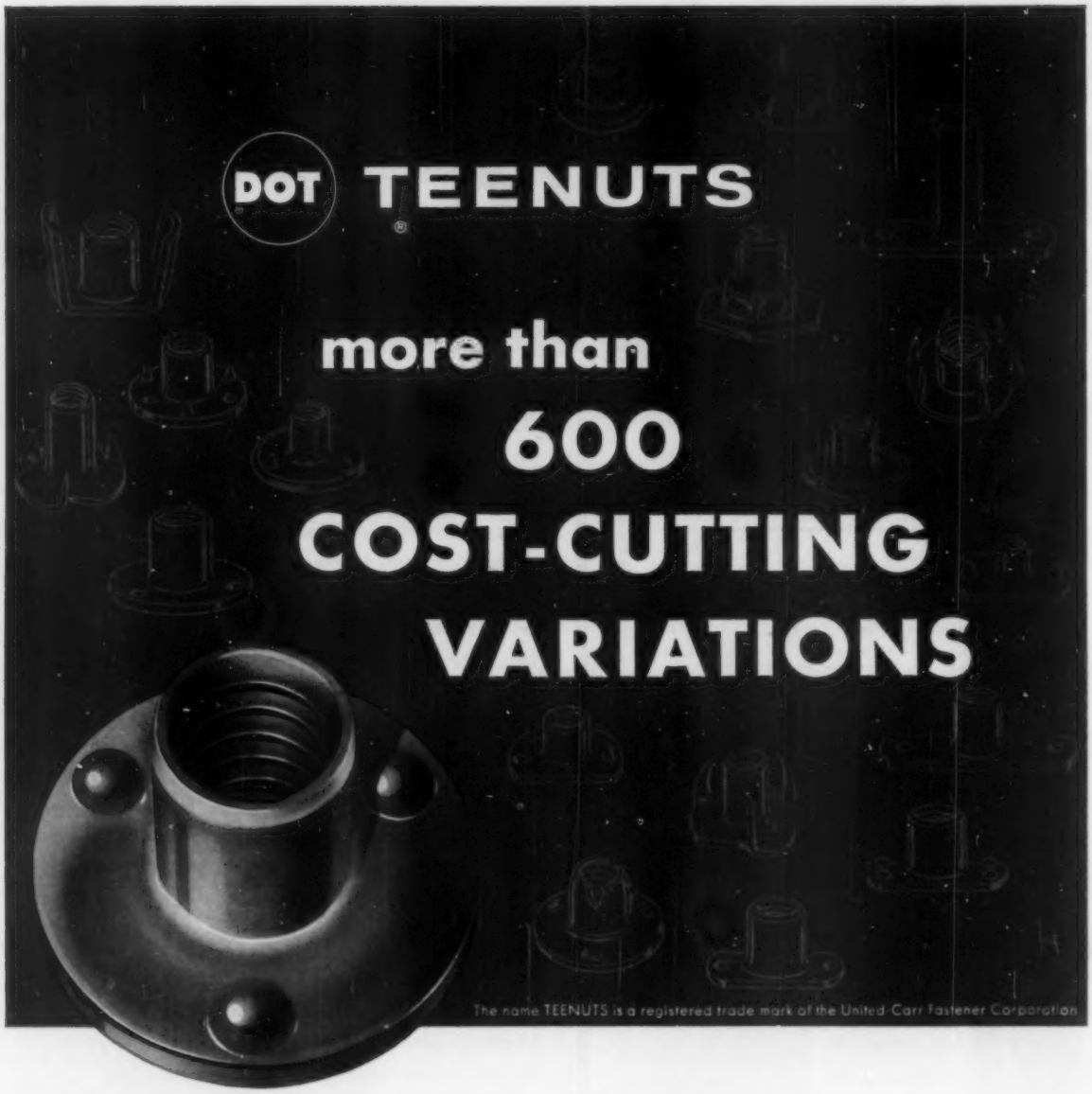
The geometry of a cylindrical roller bearing results in inherently greater radial load carrying capacity than other types. There is a larger area of contact between races and rollers and radial capacity is not sacrificed to provide for thrust. Also, straight cylindrical bearings provide better bearing characteristics because they provide true rolling motion.

If you're faced with the problem of designing more load in less space, call on your Hyatt sales engineer. He can draw on Hyatt's extensive experience in the design and manufacture of reliable cylindrical bearings to help you.

HYATT *HY-ROLL BEARINGS* **FOR MODERN INDUSTRY**

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY



Since the first TEENUT was developed by Carr Fastener in 1927, more than 600 different modifications of this extremely versatile device have been designed and manufactured in true, mass-production quantities.

By combining nut and washer in one solid unit, the DOT TEENUT offers exceptional strength and security and eliminates the need for tapping. Its flanged base can be formed with welding bosses for attachment to sheet or solid metal structures . . . with prongs for wood . . . or with any number of different special bases for particular applications. DOT TEENUTS can be made in heat and corrosion-resistant materials and they can be provided with moisture-seals and vibration-proof, self-locking barrels.

Once mounted, the DOT TEENUT stays put and can't be lost or mislaid . . . an advantage at any time and a necessity where blind fastening is required.

Wide experience in the proper application of DOT TEENUTS and a multitude of other special-purpose fasteners enables your DOT field representative to provide prompt and effective solutions to a tremendous variety of fastening problems. Where special design work is needed, he can bring you the services of a design-engineering group unequalled in its field.

The DOT TEENUT catalog is an invaluable reference . . . yours on request.

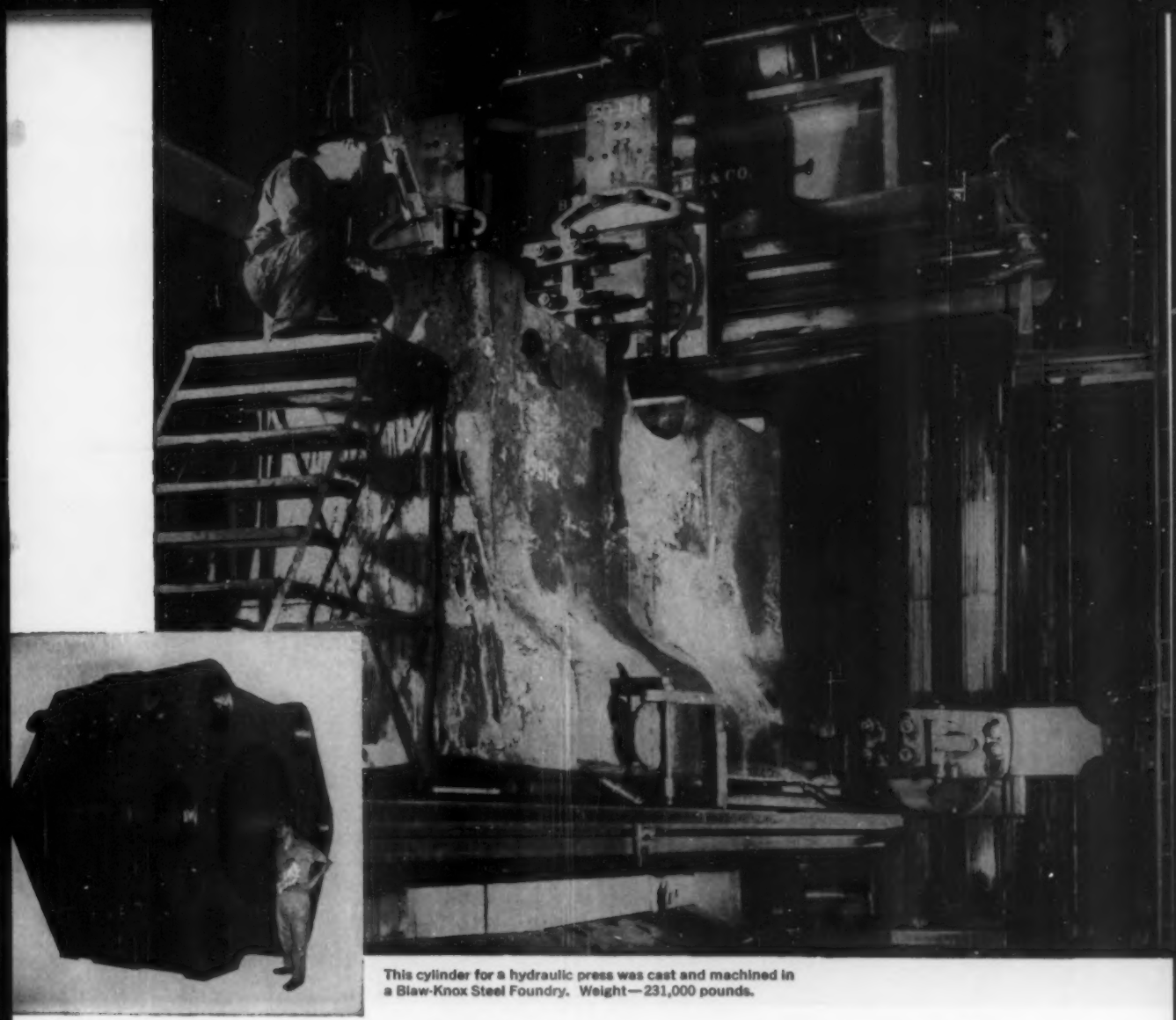
MAKERS OF DOT FASTENERS

CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, San Francisco, Seattle, Syracuse

CIRCLE 53 ON READER SERVICE CARD→



This cylinder for a hydraulic press was cast and machined in a Blaw-Knox Steel Foundry. Weight—231,000 pounds.

Blaw-Knox Steel Foundries have machine capacity to handle the most unusual product requirements

Planing, turning, milling, or boring the most unusually dimensioned casting is no problem in a Blaw-Knox Steel Foundry. There you will find planers up to 15 feet × 15 feet × 36 feet, lathes with an 84 inch swing, and planer type milling machines up to 6 feet × 6 feet × 25 feet. In the same machine shops, you will find the smallest precision tool room equipment.

This huge line-up of tools is part of the basic equipment of each of the five Blaw-Knox Steel Foundries. Because Blaw-Knox is one of the world's leading builders of rolling mills and industrial machinery, its machine shops are equipped to handle all of the operations necessary to finish a steel casting for assembly into the complete unit or sub-assembly.

Machining to exact specifications with a wide variety of tools is another way Blaw-Knox Steel Casting Service adds value to your product. There is no need to ship the rough casting to another location for machining. You have the advantage of a single responsibility from patternmaking to shipping.

If you design or build a product using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Casting Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

BLAW-KNOX

Steel Castings

Whatever your flexible metal tubing problem, Anaconda's broad design and manufacturing capability can make your job easier

The big corrugated stainless steel tubing assemblies shown above were designed and manufactured by Anaconda Metal Hose for water lines in the missile program. Construction of these 12″ I.D. lines is corrugated stainless steel flexible tubing, reinforced with stainless steel wire braiding; end fittings are floating flanges. This type of tubing can also be produced in other metals as Bronze, Steel, in standard ID's through 16″ and standard lengths of 20 feet.

Small flexible tubing for small tough jobs, too. At the other end of the scale are tiny ⅛″ Vibration Eliminators. And in between, the variety of flexible hose assemblies – in size, material, and design – is almost infinite.

Sales Engineering Consulting Services that follow through from original design to finished product. Simply let us know your needs, with conditions, dimensions, and such sketches and drawings as might be necessary to give us an understanding of your problems. We will work out design problems with your engineers and draftsmen. We will manufacture the flexible connectors. And we will make specialists available for immediate service calls on equipment or field installations. These services are available through our representatives in leading cities—see listing "Hose-Metal" in the Yellow Pages. Or write: Anaconda Metal Hose, Box 791, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

60127

ANACONDA®
Metal Hose

PRODUCT ENGINEERING HORIZONS

December 12, 1960

Feller Named Sam

Once there was in our town a feller named Sam. Big galoot, kind of ungainly, but smart and handy. Could use both his head and his hands better'n most. Helped his neighbors, too, either on current chores or with a little loan now and then. But he had so much and could do so much—and did—that he never really was what you'd call popular. Even his own relatives were always picking at him—straightening his tie, or pointing out a spot on his shirt, or suggesting he get a haircut.

Down the road a piece, there was another big guy, from an older family but younger than Sam. He was always flexing his muscles, was Ivan, always beating his chest. He'd made a lot out of the family farm in a short time, too, fixing up the buildings, buying machinery, helping the ground. He'd had a couple of farmers next door with little places. Ivan sort of put them in a bind and took 'em over. He kept making offers to other farmers, too—lend 'em a little help or a machine or some seed. All they had to do was join a cooperative he was setting up.

Seemed funny to watch, sort of. Here was Sam being helpful with no strings, and Ivan always having an angle. Sam never interfered with people; Ivan kept on doing it, making big noises in town meetings, waving his fists, yelling he'd walk out on the town. Seemed a little hard to do, but he claimed he was going to.

Some people believed him, too. After all, he had made his pile, and in jig time. And he seemed to be tough enough that it was best to stay on his good side. And he was growing faster than Sam—both his farm and himself.

When somebody mentioned this to Sam, Sam grinned and said, "When I was 15, I grew like a weed, but after 18, I sort of tapered off. Ivan's a little young yet. He'll taper off, too."

Ivan kept right on beating his chest, but being pretty smart at the same time. When he lent somebody a tool, he brought it over; when he gave somebody seed, he sent along a jug of cider. Sam just sent over what was asked for, if he had it and if he felt the feller who asked really needed it. And this last sort of irked the borrowers; they figured Sam just ought to share what he had, no questions asked.

Actually, both Sam and Ivan had some pretty positive ideas about how things ought to be done by the neighbors, strong enough that both ended up running for town board. They stumped up and down calling on neighbors and selling their ideas, and each tearing down the other guy a little more each call. They did such a good job of it, in fact, that the folks all went out and voted middle of the road—for a third feller who hadn't even campaigned.

R. Langeman

MARLIN-ROCKWELL

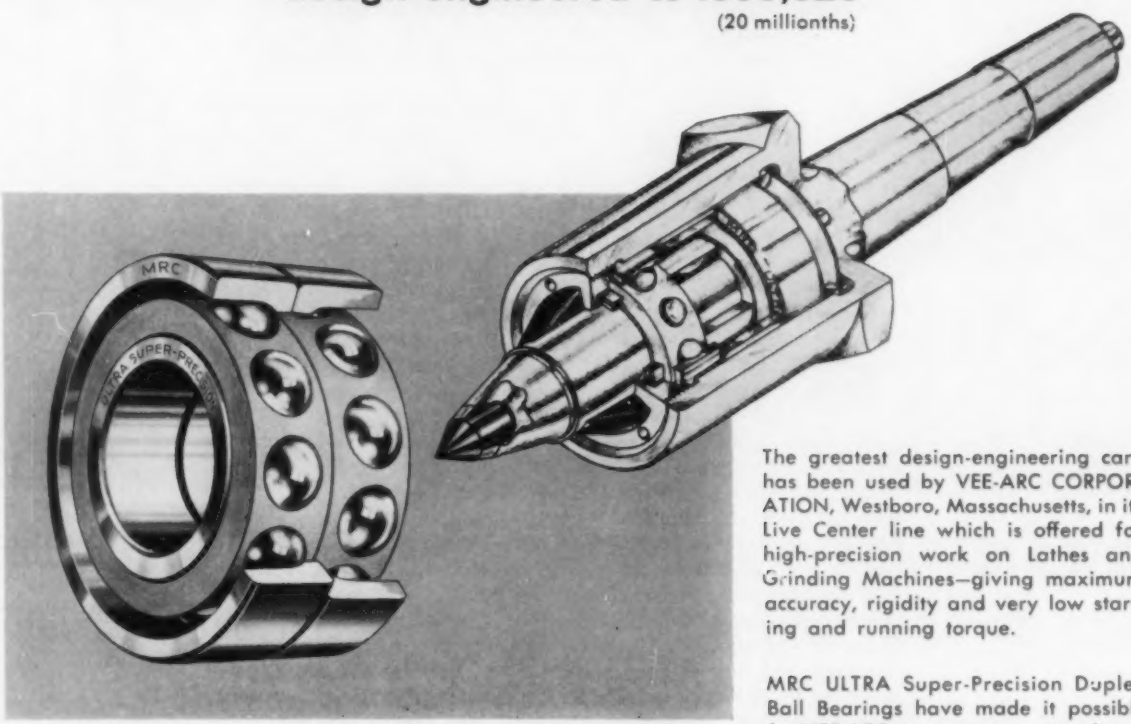
RELIABILITY

COUNTS

IN VEE-ARC SUPER-PRECISION Live Centers..

design-engineered to .000,020"

(20 millionths)



The greatest design-engineering care has been used by VEE-ARC CORPORATION, Westboro, Massachusetts, in its Live Center line which is offered for high-precision work on Lathes and Grinding Machines—giving maximum accuracy, rigidity and very low starting and running torque.

MRC ULTRA Super-Precision Duplex Ball Bearings have made it possible for VEE-ARC to guarantee a total run-out accuracy of 20 millionths of an inch, combined with low starting and running torque.

MRC pioneered, developed and produces ULTRA Super-Precision Ball Bearings to provide the ultimate in accuracy.

Consult OUR Engineering Department on YOUR Bearing Problems

MRC BALL AND ROLLER bearings

MARLIN-ROCKWELL CORPORATION

Executive Offices: Jamestown, N. Y.

PRODUCT ENGINEERING

SAMPLING THEORY —an exercise in probabilities

How well does a sample represent the whole? Here's an explanation of the equation and a graphical plot to speed computation.

RICHARD M KOFF, *assistant managing editor*

It's the statistician's creed: Samples drawn from a large lot must be Random, Representative and Adequate. The first two conditions are difficult enough to satisfy but that third qualification sets many a man to scratching his head. What is an adequate sample? Or, stating it another way, how adequate is the sample that has been drawn?

There is an equation that applies, but it is not easy to solve. It is known to statisticians (who derived it) and quality-control supervisors (who use it) but how many engineers know what it means and, more important, where it applies? It has broad application: experiments in stress and strain, environmental tests, reliability tests, price and availability averages, opinion polls, the number of blondes in Chicago—anything, in short, where the prevalence of a single characteristic of a large population of individuals is to be established on the basis of a small sample.

The population

The equation assumes that sampling is from an infinitely large lot—people, experiments, automobiles—and this is called the population. The population may or may not actually be infinite; statistically it doesn't matter so long as it's sufficiently large. The total population may not even exist yet; it can be imagined.

Within this infinitely large population are some members that have a certain characteristic, others that do not. It may be a desirable characteristic (unmarred surface finish, say) an undesirable one (flawed castings), or neither (hair color). It may be a yes-no thing (rejects on a production line), or an infinitely variable characteristic (temperature on Saturdays) but then an arbitrary dividing line is used to separate the population into two parts—those members above and those below the line. Any go/no-go characteristic will do. We want to know what percentage of the total population shares this characteristic. Let's call this percentage p and recognize that p refers to the percentage of the total population whether such a population exists or not.

The sample

To determine p you could examine every member of a population and keep a cumulative tally of the "yeses" and the "noes" and possibly even a running percentage (yeses/total examined). However, an infinite number of examinations would take a discouragingly long time. Further, after a large number of examinations you find that the percentage will settle down and change only very slightly for each additional examination.

Obviously, somewhere along the line it pays to stop. The purpose of the equation given below is to help establish a stopping point. What we are dealing with here is a sample of the total population and we will call the sample size N.

Sample size N is more than a number. A number may seem all that is important from an idealized point of view, but in real-life situations, the character of the sample is also important. The sample must be truly representative of the population as a whole; it makes no sense to try to establish the voting preferences of the nation, for example, with a sample taken from a list of registered Republicans. This is obviously a biased sample—but other, less obvious biases are possible and they must be avoided. Experience is the best judge of a sample. The man who has to devise many sampling systems knows how easy it is to overlook important influences. To this end he will sometimes be seen throwing dice or shuffling cards or consulting printed tables of random numbers (is this the ultimate absurdity?) in order that his selection of a sample will not be influenced by some built-in preference for certain numbers.

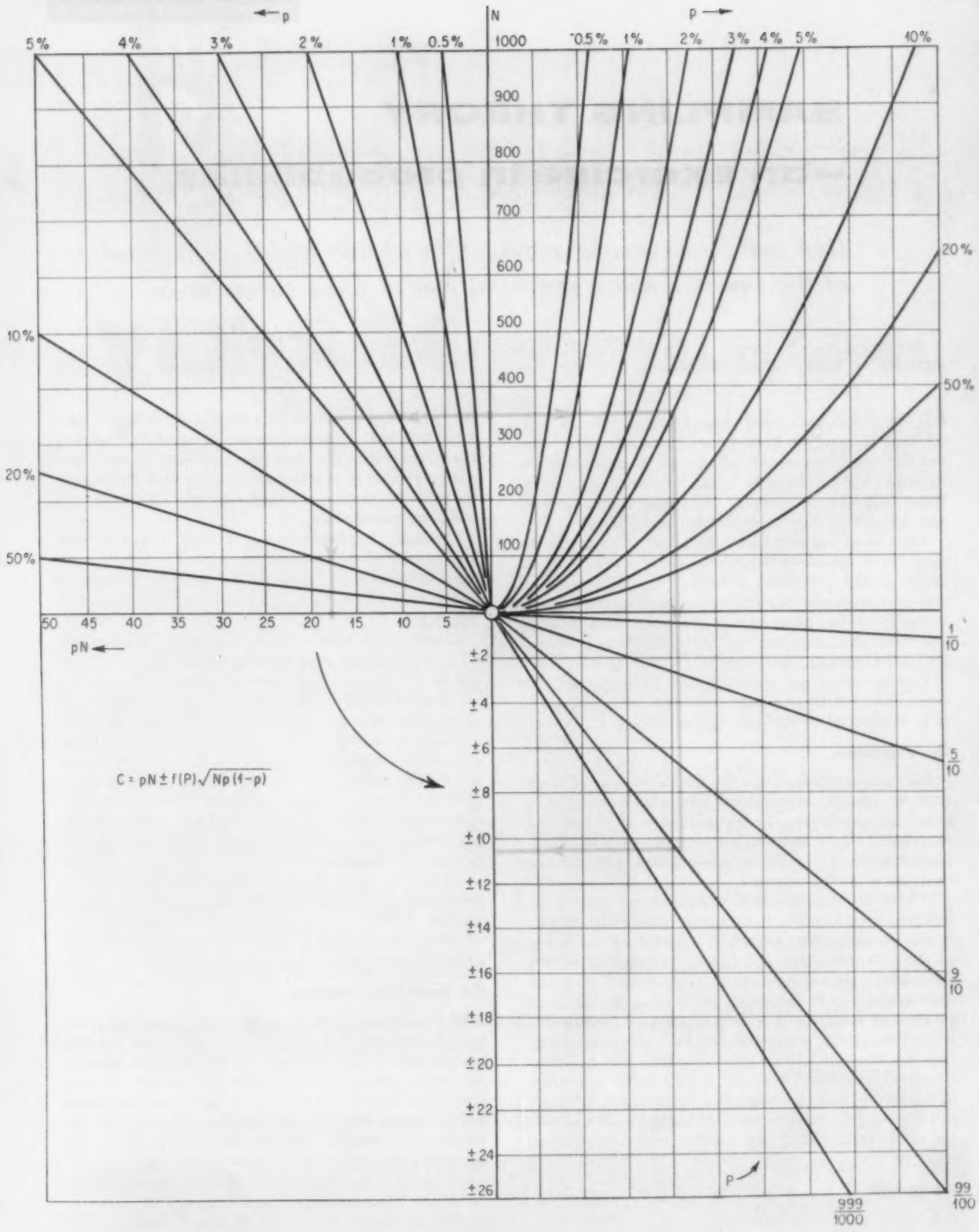
The probability function

If a percentage p of an infinite population has a certain characteristic, one might expect that in any representative sample N, pN will have this characteristic. Actually any single sample would be extremely unlikely to have exactly this number. It is far more likely that the sample will have a few more or a few less than pN. However, the average of all samples will have this number—that is the way p was defined.

Let us call c the number of individuals in the sample sharing the characteristic. Thus the average of all c's for an infinite number of samples of size N would be pN. Any individual sample N, however, would have a c that

REPRINTED—Circle P72, inside back cover

SAMPLING THEORY continued



varied above or below pN by an amount depending on the probability distribution of all such samples. The distribution is assumed to be "normal" or Gaussian and so the limits of c above and below the expected pN for a particular sample can be defined in probability terms.

Thus one can say, for example: samples of 100 castings drawn from an infinite population of castings having a process reject ratio p of 5%, will have an average of 5 rejects. BUT, any single sample will have:

- in 35 cases out of 100,
  no fewer than 4 nor more than 6 rejects;
- in 64 cases out of 100,
  no fewer than 3 nor more than 7 rejects;
- in 83 cases out of 100,
  no fewer than 2 nor more than 8 rejects;
- in 98 cases out of 100,
  no fewer than 0 nor more than 10 rejects.

What this series of statements says is that if the accuracy of the prediction is to increase, the spread must widen. The exact equation describing this relationship is

$$c = pN \pm f(P)\sqrt{pN(1-p)}$$

where N is the sample size, p is percentage of the total population having a certain characteristic, c is the lowest or highest number (note $\pm$ sign) with that characteristic in any given sample, P is the probability associated with the range of c's.

The function of P preceding the radical is derived from tables listing areas under any part of a normal curve (found in most statistical texts). The area under the middle of the curve, to a given distance on either side of the mean is a proportion of the area under the entire curve. This proportion is the probability P. Distances from the mean are usually measured in sigmas (number of standard deviations) and $f(P)$ is equal to the number of sigmas for the given proportion P.

The graph

A sliderule could make short work of the equation except for that $f(P)$—looking up the appropriate figure for each probability will slow you down considerably. To spare you the trouble of the table, here are some convenient figures:

$$f\left(\frac{1}{10}\right) = 0.126 \qquad f\left(\frac{99}{100}\right) = 2.575$$

$$f\left(\frac{5}{10}\right) = 0.674 \qquad f\left(\frac{997}{1000}\right) = 3.00$$

$$f\left(\frac{9}{10}\right) = 1.654 \qquad f\left(\frac{999}{1000}\right) = 2.30$$

So that if you want to be correct 997 times in 1000 in the casting example mentioned above

$$c = 0.05 \times 100 \pm 3.0\sqrt{100 \times 0.05\,(1 - 0.05)}$$

$$c = 5 \pm 6.54$$

Obviously the number of rejects can't go under zero or be a fraction so

$$c = 0 \leqq 5 \leqq 12$$

The equation has been plotted to eliminate even this much work. The plot also permits working the problem backwards—starting with a range in c and a sample size N, and finding p—a nasty problem if it has to be done algebraically.

In this graph N is scaled from the center straight up. Curves of constant p sweep up on either side of the N axis. The lines in the left quadrant are less important but they are included as a convenience for finding product pN—a computation that can often be done mentally.

To use the chart when sample size N and reject rate p are known, find pN from intersection of p and N in left quadrant. A similar intersection in the upper right quadrant may be traced down to the appropriate P curve, and the plus and minus value read from the left axis.

Alternatively with any three of the four variables—c, p, N, or P,—the fourth may be found by tracing a rectangle on the chart similar to that shown in color.

For REPRINT of above article, just check P72 on one of the Reader Service cards found in this issue.

Now available, a combined reprint on

THE NEW MATHEMATICS

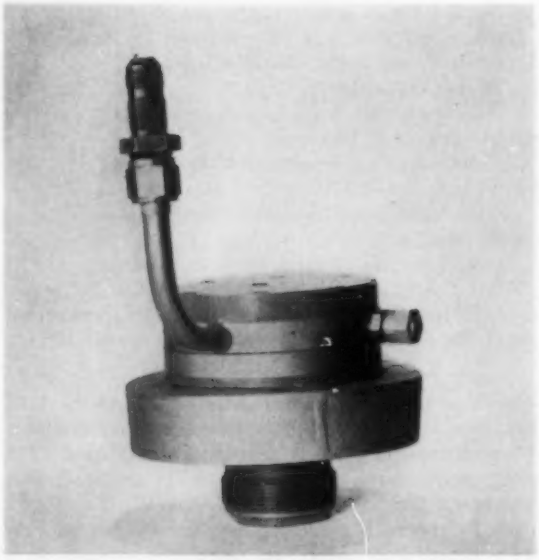
18 articles, 64 magazine-size pages, on the latest in the systems engineer's tool kit.
Some of the subjects covered in depth:

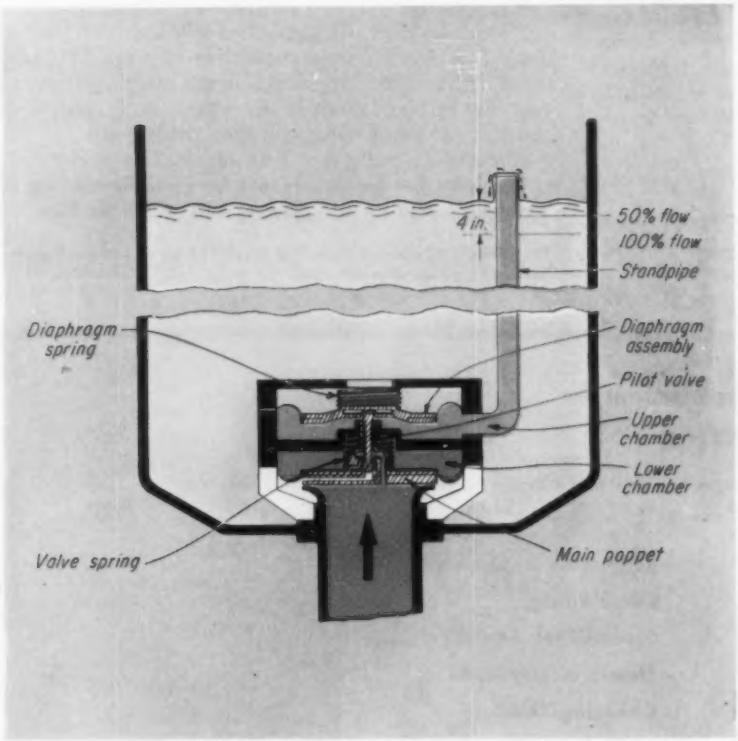
Linear Programing	**Regression Analysis**
Dynamic Programing	**Curve Fitting**
Design of Experiments	**Dimensional Analysis**
Latin Squares	**Theory of Similitude**
Multivariable Experiments	**Queueing Theory**

Copies of this combined reprint are available at $2 each, including postage.
Send order with remittance to: Reader Service Dept, Product Engineering,
330 W 42nd St, New York 36.

Fills Tanks Precisely —Without Floats

Control valve balances hydrostatic head in standpipe against that of fluid rising in tank. Near equilibrium, valve gradually closes, stopping inflow at preset level.





PS . . . Valve controls final shutoff level to ± 0.1 in. of desired level, with flows of 0 to 200 gpm and dead-head pressures of 10 to 50 psi. Maximum inlet pressure during closure was 61 psi when valve was tested with a dead-head pressure of 50 psi. For valve shown, cracking pressure and pressure drop for flows up to 150 gpm need not exceed 0.5 psi with a pilot head of 50 ft. Floatless level-control valve is produced by Whittaker Controls Div, Telecomputer Corp, Los Angeles.

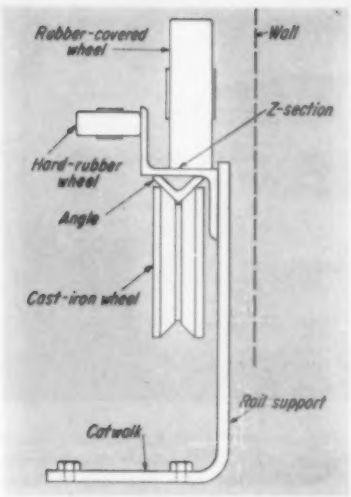
INITIAL PRESSURE at valve inlet opens the main poppet which closes again as pressure rises in lower chamber. Then liquid enters the upper chamber through the pilot valve and fills the standpipe, producing hydrostatic pressure in both chambers. This pressure raises the diaphragm assembly in the upper chamber, compressing the diaphragm spring. Starting with the valve empty, as during initial operation, this takes about 10 seconds.

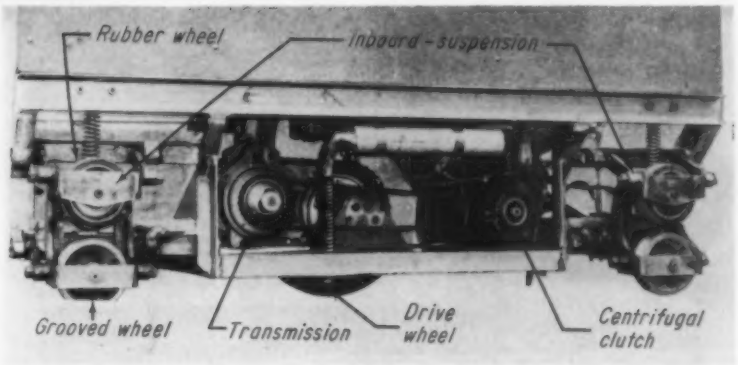
As the diaphragm assembly rises, it lifts the pilot valve off its seat, closing the upper passage to inlet pressure and allowing the liquid in the lower chamber to escape to the tank. With the pressure in the lower chamber reduced, inlet pressure again raises the main poppet and fills the tank.

As the tank fills, hydrostatic pressure on the upper side of the diaphragm assembly rises. When the fluid is within approximately 4 in. of the desired level, the hydrostatic head and spring force on the upper diaphragm are in equilibrium with the hydrostatic head in the standpipe. Further filling increases the pressure on the top of the diaphragm, allowing the diaphragm spring to reposition the pilot valve. The main poppet follows position of the pilot valve as it gradually closes. This continues until the main poppet is completely closed—which occurs when the liquid level is approximately 2 in. below the upper end of standpipe.

Rail Guides Car for Tunnel Police

Two inboard suspension units grip the track while single outboard wheel drives car forward or backward at speeds up to 30 mph.

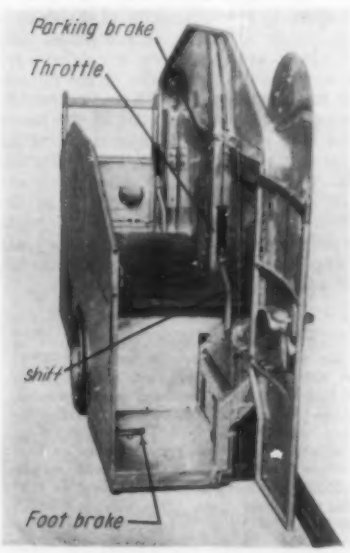




SINGLE DRIVE wheel also serves as outboard support. Pneumatic tire provides comfortable ride and avoids use of springs, which would permit excessive vehicle movement. Perforated metal flange on drive wheel permits vehicle to keep moving even if pneumatic tire is punctured. Three-wheel combinations, mounted inboard at each end, support and guide the car. Rails on which these wheels run consists of a light steel Z-section with an inverted steel angle welded to it. Rail is welded to steel supports bolted to catwalk floor.

The upper hard-rubber wheel runs on the leg of the Z, helps support the vehicle. The cast iron grooved wheel runs on the inverted angle and minimizes horizontal movement. The hard-rubber wheel running against the flange of the Z minimizes tilting of the vehicle cab. Mounted on a four-bar parallel-arm linkage, the three wheels are spring-suspended to permit vertical motion when the vehicle runs over bumps in the catwalk surface.

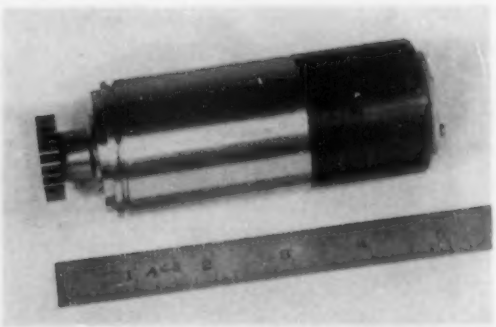
Drive wheel is powered by an 8-hp gasoline engine through a centrifugal clutch and transmission connected by chain drives. The transmission provides forward, neutral and reverse and can be shifted under full load. Reduction is the same in both forward and reverse; clutching is not required for shifting. Foot pedal operates braking system, which is similar to that of an auto. A safety bar operates the mechanical parking brake. Engine speed is controlled by a twist grip on the shift handle.

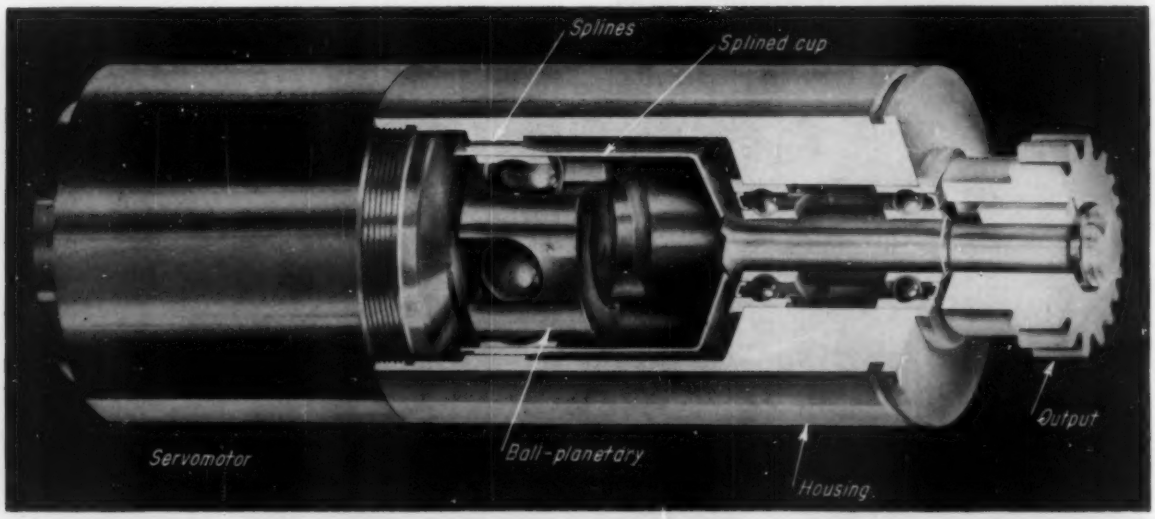


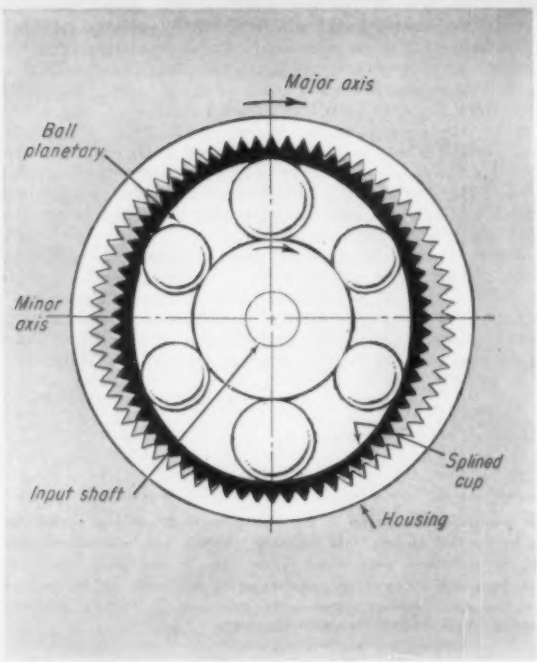
PS . . . Tunnel-catwalk transportation system is part of automated policing system for vehicle tunnels operated by the Port of New York Authority. Vehicle can be combined with automatic alarm system, so patrolmen need enter tunnel only in emergency. Gasoline-powered vehicle is 74 in. long, and 20 in. wide; operates at 30 mph, with an acceleration of 2.6 mph/sec. Tunnel car and guidance system were developed at Battelle Memorial Institute, Columbus, Ohio, by R. D. Fannon, research engineer.

TRULY Flexible Gears for High Ratios

The output shaft of this servomotor unit has a flexible splined cup, so high reduction ratios are possible in a small space. Efficiency is high; ratio changes, simple.



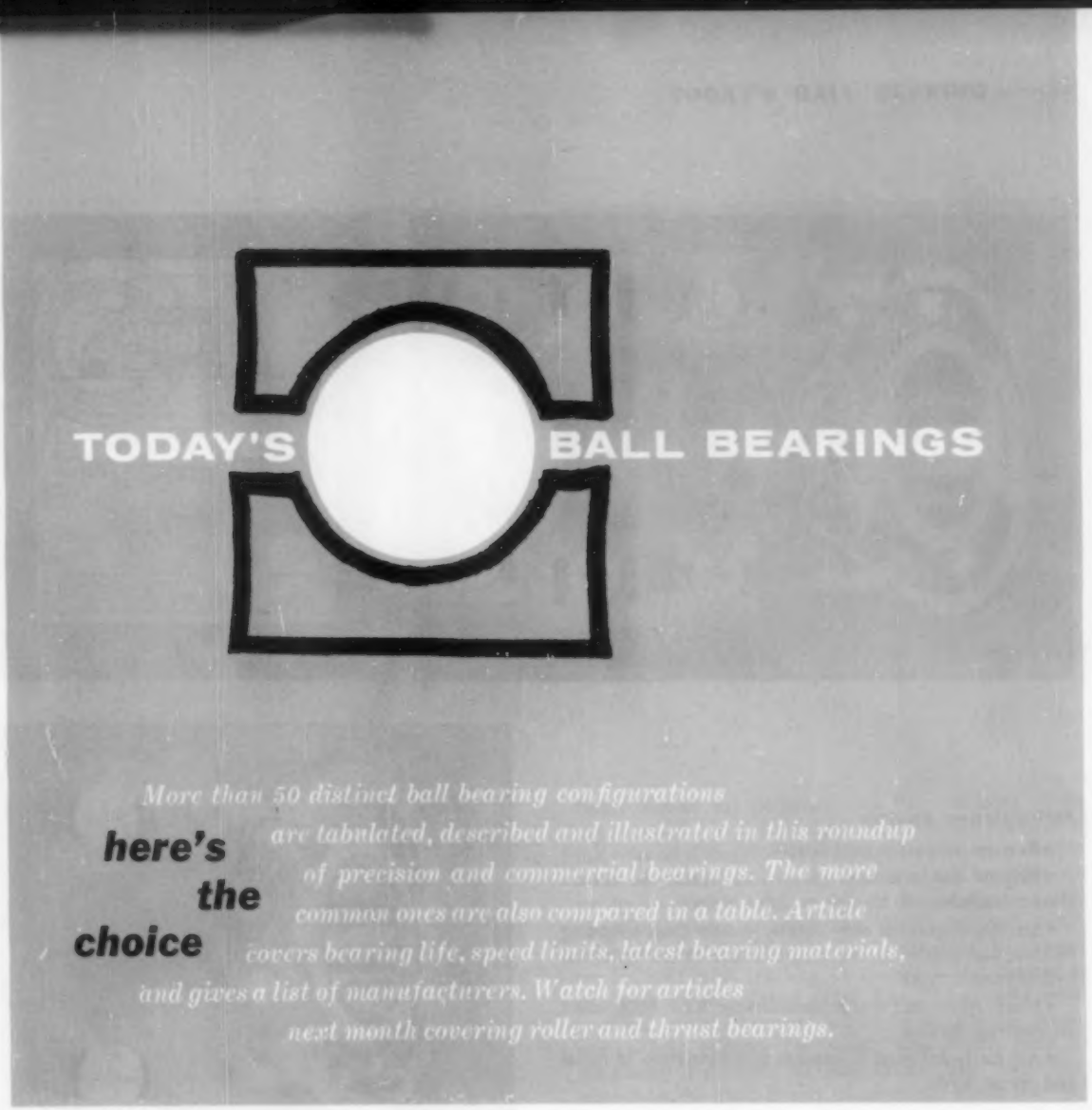




HARMONIC DRIVE unit includes the servomotor; 6-ball planetary; flexible splined cup and output shaft, housing with internal splines, output gear and bearings. There are 219 teeth on the splined cup and 221 inside the housing.

Ball-planetary driven by input shaft from servomotor generator revolves, it deflects the thin walls of the flexible balls graduated in size from 0.4063 in. at the major axis to 0.3962 in. at the minor axis. As the elliptical-wave generator revolves, it deflects the thin walls of the flexible cup, bringing its teeth into engagement with mating splines on inside of the housing. Engagement occurs at the major axis of the generated ellipse and disengagement at its minor axis. Length of the cup wall acts as a deflection attenuator, providing an integrated coupling between spline engagement at one end and output shaft at the other. At rated speed there are approximately 10,000 spline-tooth contacts per second. Since there are two teeth less on the splined cup than on the housing spline, the cup rotates backward at greatly reduced speed.

PS . . . Gearhead has servomotor reduction ratio of 370:1 with torque rating of 600 oz-in. and peak overload of three times this value. At this ratio, units produced to commercial manufacturing tolerances have less than 2 min. backlash. Different ball-planetary units can provide reduction ratios from 240:1 to 480:1; ellipsoidal bearings provide ratios as low as 110:1. Compact assemblies of Harmonic Drives with reduction-ratio limits of 1,000,000:1 are practical according to the developer, United Shoe Machinery Corp. (For more on basic principles, see *PE—Feb 8, p 47.*)


TODAY'S BALL BEARINGS
here's the choice
More than 50 distinct ball bearing configurations are tabulated, described and illustrated in this roundup of precision and commercial bearings. The more common ones are also compared in a table. Article covers bearing life, speed limits, latest bearing materials, and gives a list of manufacturers. Watch for articles next month covering roller and thrust bearings.

NICHOLAS P. CHIRONIS
Associate Editor

a PRODUCT ENGINEERING special report

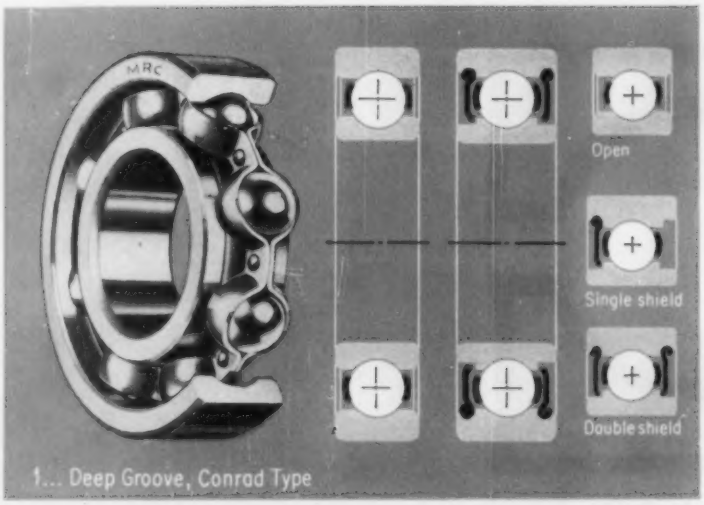
The product designer today is faced with a bewildering array of ball and roller bearings. It is not easy to pinpoint the most suitable type for the specific need. Yet each type meets a certain demand—hence its listing in bearing catalogs.

The problem is further complicated by the fact that there is no definite application distinction between various types or, for that matter, between the two categories—ball and roller bearings. For a particular application—say, machine-tool spindles—any one of a half dozen different types, ball and roller, paired in various combinations, are found being used successfully. The final decision therefore has to be one of comparison and compromise.

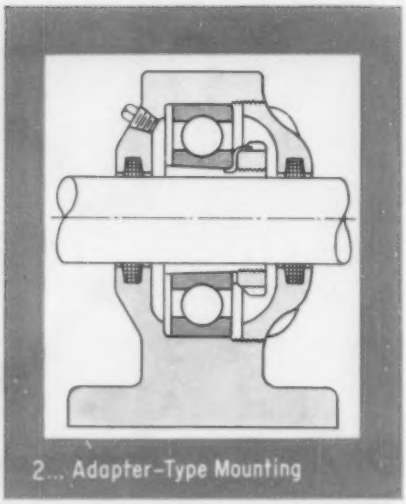
This article is limited to ball bearings—except for a few very specialized ones, all major types are rounded up here. PRODUCT ENGINEERING will next cover roller and needle bearings; also thrust bearings—both roller and ball types.

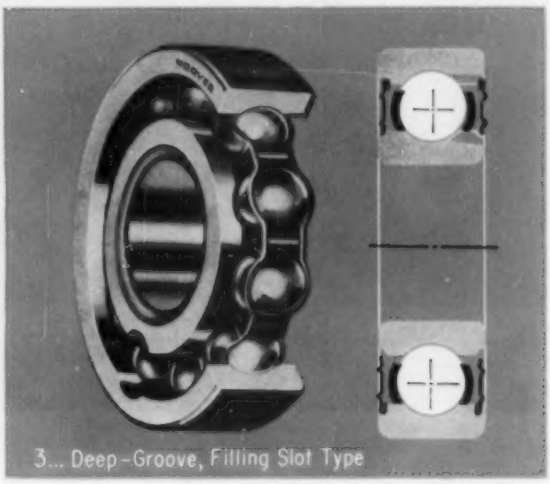
A good way to begin a comparison between ball and roller bearings is to compare both with still another major class—the hydrodynamic journal bearing. continued, next page

Copyright 1960 by the McGraw-Hill Publishing Co Inc



1... Deep Groove, Conrad Type


2... Adapter-Type Mounting


3... Deep-Groove, Filling Slot Type

Rolling-element bearings

- Require a shorter axial length
- Require only a limited quantity of lubrication and are almost insensitive to changes in lubrication
- Starting friction is only slightly greater than operating friction, and usually considerably less than for conventional hydrodynamic types
- Load, speed and temperature-change have little effect on running friction
- Are easily designed to support a combination of radial and thrust loads

Hydrodynamic bearings

- Are considerably quieter
- Are less subject to fatigue failure; they can provide almost unlimited service
- Require less housing-bore space
- Are less expensive in initial and assembly cost

BALL BEARINGS vs ROLLER BEARINGS

It is now easier to make a general comparison between the two major classes that use rolling elements:

Ball bearings

- Have lower friction torque at light loads
- Can run at higher speeds without undue heating
- Provide fewer mounting and design problems
- Are available in a wider variety of sizes
- Can be made in smaller sizes
- Can be obtained more frequently with seals and shields for easy lubrication
- Are less expensive in cost per pound of load-carrying capacity for light loads

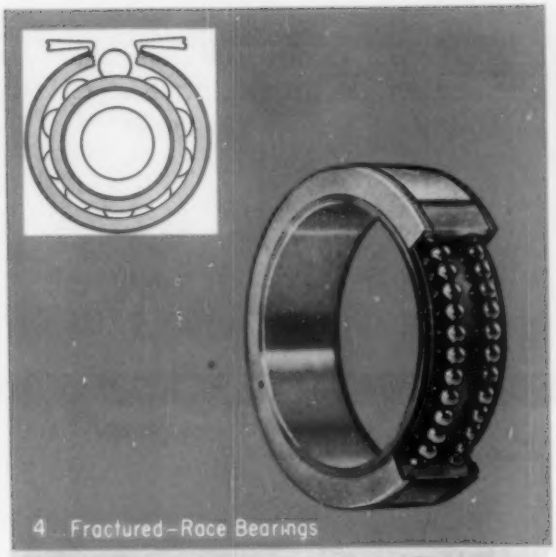
Roller bearings

- Sometimes have lower friction at heavy loads
- Can carry heavier loads
- Are more satisfactory under shock or impact loading
- Provide greater rigidity
- Are less expensive for the larger sizes and heavier loads

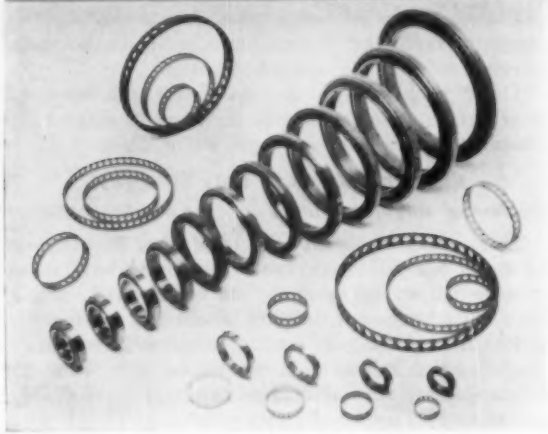
DEEP-GROOVE BALL BEARINGS

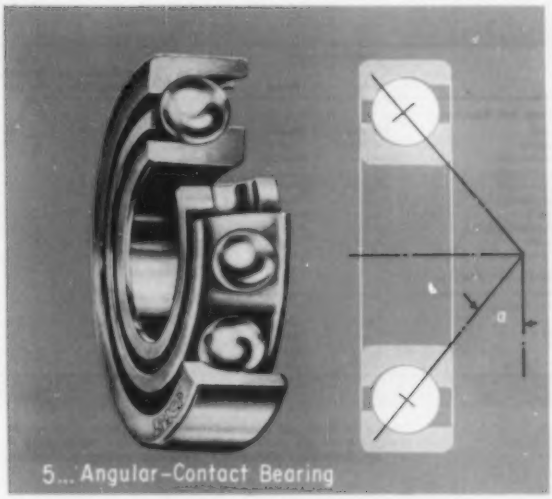
Single-row Conrad

This is the most popular ball bearing, Fig 1. The balls, when under radial load, contact the races in a vertical line. Under thrust load, the rings are slightly displaced axially with respect to each other and the balls contact at a position on the sidewall of the races. Thus a line passing through the centers of the contact areas would



4... Fractured-Race Bearings





5... Angular-Contact Bearing

be at a small angle from the radial center of the bearing.

The Conrad bearing can carry both radial and thrust loads, the latter equally well from either direction. Grooves are deep and their radii are generally only 2 to 4% greater than the ball radius. This results in a high degree of osculation (contact area) between ball and race. In fact it is sometimes more satisfactory for carrying thrust loads than is a thrust bearing (because of the possibility of radial loads). It is available with a wide variety of shields and seals, many of which have been described in a previous report ("Which Type of Integrally Sealed Ball Bearing," Feb 29, p 54). It is not usually made as a double-row type.

The Conrad bearing is assembled by displacing the inner ring along a radius to permit insertion of the balls in the crescent-shaped gap. The balls are then spaced evenly around the periphery, and the two sides of the cage inserted and riveted together. Main disadvantage of this method is that it does not permit a maximum complement of balls. Two ways of obtaining full complements are by employing a filling slot, or by employing a split (fractured) inner or outer race, (both discussed later).

Adapter mounting—Some bearings, including the Conrad, are available with the bore of the inner ring tapered to receive a tapered adapter sleeve, Fig 2. This split sleeve is drawn into the tapered bore by means of a nut on one end, tightly gripping the shaft. This avoids need for machining a shoulder on long shafts. The wide, tight seating on the shaft is also an advantage where the shaft is made of cold-rolled steel or subjected to considerable shock and vibration.

Single-row filling slot

In this type of deep-groove bearing, slots or notches are cut on one side of the shoulders of both rings, Fig 3. This allows more balls and produces a bearing with a high radial capacity. But the bearing cannot take large thrust loads in the direction of the notch; in practice, therefore, it often has essentially no greater capacity than the Conrad type under conditions of combined load.

A filling notch is not advisable for precision ball bearings that operate at very high speeds because the nonuniform stress distribution in the vicinity of the notch makes it difficult to achieve the close tolerance required.

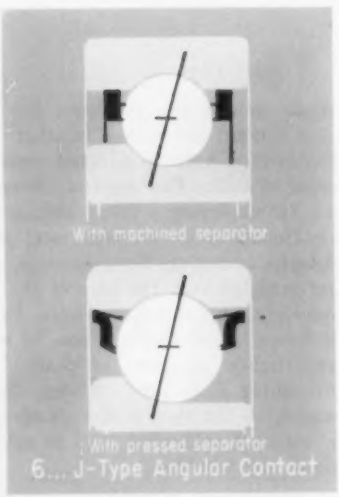
Fractured-race bearings

The outer ring of these deep-groove bearings is scored and fractured so that it can be opened to permit a maximum complement of balls (see Fig 4). The open ring closes elastically and is secured in place by various methods, depending on application. In contrast to the Conrad or

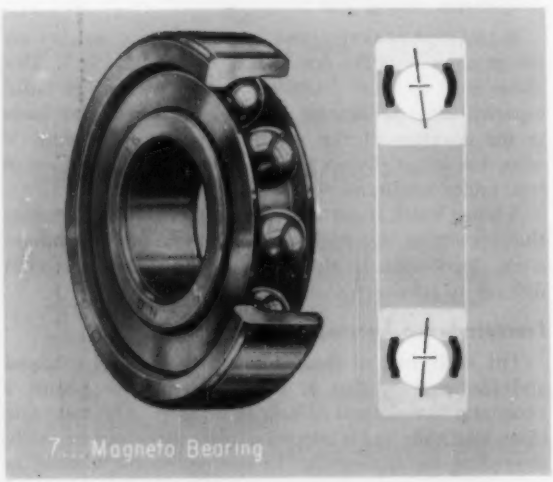
PERFORMANCE CHARACTERISTICS OF BALL BEARINGS

Type	Relative Capacity		Direction of Thrust—	Permissible Ratio,	Number of Bearings Required	Relative Characteristics*							
	Radial	Thrust	Single or Double	Thrust/Radial	for Shaft Location	Permissible Speed	Friction Torque	Noise	Mounting Ease	Take Moment Loads?	Absorb Mounting Errors?	Radial Rigidity	Axial Rigidity
Single-row Ball Bearings:													
Conrad	Medium	Medium	Double	Any	One	2	1	1	1	3	3	4	4
Filling-slot	Med-Heavy	Light	Double	< 0.6	One	3	2	3	1	3	3	3	4
Fractured-race	Med-Heavy	Medium	Double	Any	One	2	1	1	1	3	3	3	4
Angular-contact													
Small angle (15°)	Medium	Med-Heavy	Single	0.5 to 1.0	Two	1	2	1	4	4	2	3	2
Large angle (40°)	Medium	Heavy	Single	> 1.0	Two	2	3	2	4	4	2	3	2
J-Type	Medium	Med-Heavy	Single	0.5 to 1.0	Two	1	1	1	4	4	3	3	2
Four-point Contact	Medium	Medium	Double	Any	One	4	4	4	3	2	4	1	1
Magneto	Light	Light	Single	< 0.5	Two	4	3	3	4	3	3	4	4
Self-aligning	Light	Light	Double	Any	One	3	1	3	1	None	1	3	3
Double-row Ball Bearings:													
Double-row Angular-contact	Heavy	Heavy	Double	Any	One	3	3	3	1	4	3	3	3
Duplex Bearings													
DB	Heavy	Heavy	Double	Any	One pair	2	4	1	2	1	4	2	2
DF	Heavy	Heavy	Double	Any	One pair	2	4	1	3	4	1	2	2
DT	Heavy	Very Heavy	Single	Any	Two pair	2	3	1	3	4	4	3	1
Self-aligning	Medium	Light	Double	Any	One	1	1	2	1	None	1	3	3

Rated in terms of desirability, from 1 (best ranking) to 4. These values are only relative and do not necessarily hold true for all applications. Difference between rating and 4 is often narrow.



6... J-Type Angular Contact


7... Magneto Bearing

filling-slot types, the fractured-race permits use of one-piece cages, which are better balanced than the two-piece types. Recently this fractured-race technique has been extended to include double-row bearings.

This type of bearing is also made with both inner and outer races fractured to simplify replacements without disassembling many other parts of the machine.

ANGULAR-CONTACT BALL BEARINGS

Single-row angular contact

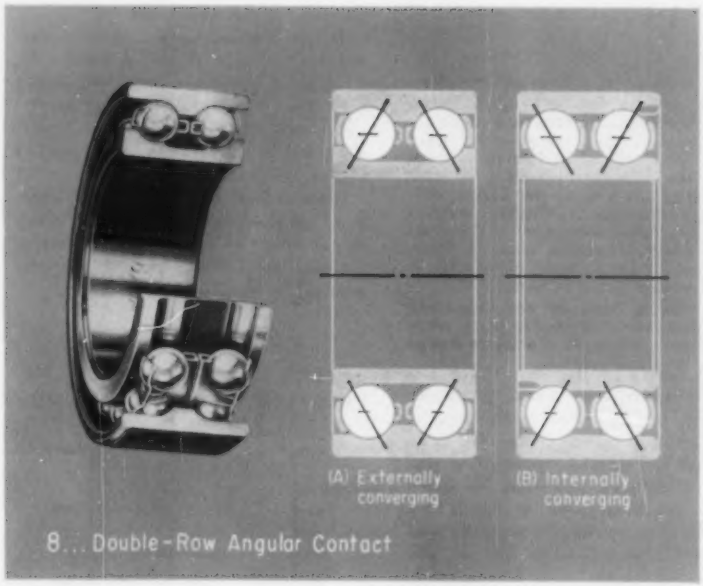
These are usually made with high thrust shoulders on all except one side of the outer ring where the shoulder is only high enough to make the bearing nonseparable, Fig 5. The location of the races is such that the direction of load through the balls forms an angle with the vertical (angle α) that usually does not exceed 40°. Thus the bearing can support a thrust load from one direction only, or a thrust load combined with a radial load. Thrust capacity is high because the bearings can be assembled with a large number of balls, without use of a filling slot.

A single-row type mounted singly cannot carry a pure radial load. There must also be thrust against the back face of the outer ring. Therefore this type is nearly always applied in pairs, mounted opposed—that is, with one bearing at each end of the shaft; or two actually butted together; or, when the side surfaces are flush-ground, in multiple combinations. The single-row type is sometimes available with three different contact angles giving a variety of radial-thrust carrying characteristics.

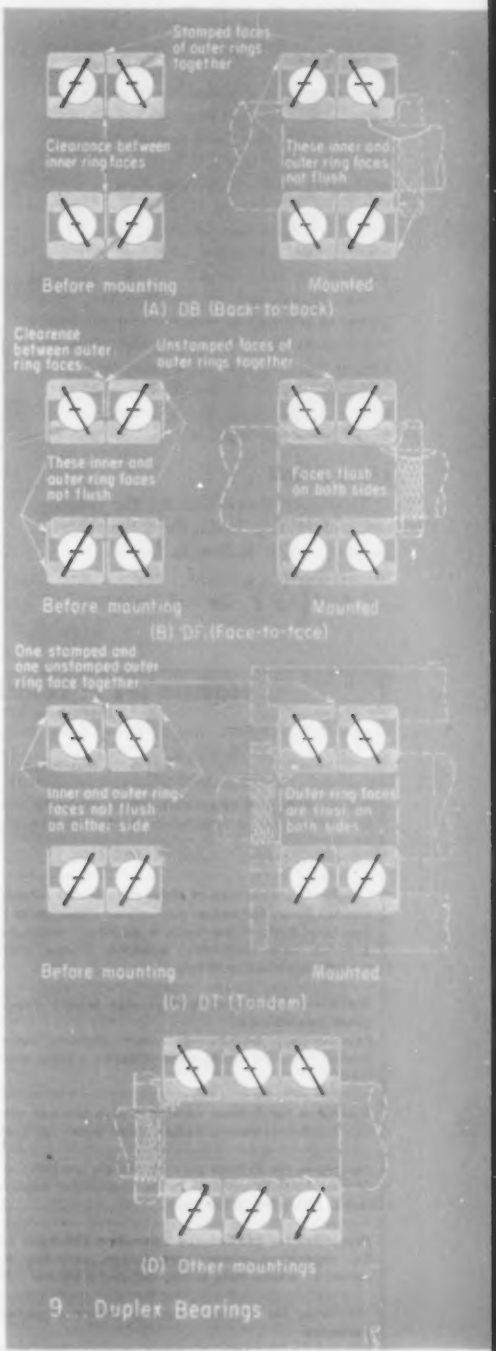
J-type angular contact

This bearing is similar to the conventional single-row angular contact except that the non-thrust shoulder is counterbored only on the inner instead of the outer ring, Fig 6. This permits its use for higher speeds because:

- Cages of one-piece construction can be employed. These are better balanced than 2-piece configurations.
- Cages can be designed to be supported on the two lands of the outer race.



8... Double-Row Angular Contact


Stamped faces of outer rings together
Clearance between inner ring faces
These inner and outer ring faces not flush
Before mounting
Mounted
(A) DB (Back-to-back)
Clearance between outer ring faces
Unstamped faces of outer rings together
These inner and outer ring faces not flush
Faces flush on both sides
Before mounting
Mounted
(B) DF (Face-to-face)
One stamped and one unstamped outer ring face together
Inner and outer ring faces not flush on either side
Outer ring faces are flush on both sides
Before mounting
Mounted
(C) DT (Tandem)
(D) Other mountings
9... Duplex Bearings

• The double-shoulder outer race avoids the danger of balls approaching a counterbored anti-thrust shoulder.

Magneto bearings

Magneto bearings, Fig 7, resemble conventional single-row angular contact, except that angle of contact is small and these bearings are made without a second shoulder on the outer ring. Result is they can be easily disassembled by removing the outer ring endwise so that the rings can be applied separately to housing or shafts.

Because degree of osculation between outer ring and balls is rather low, bearing capacity is small. These bearings must be applied in pairs, opposed to each other under a light thrust load sufficient to assure positive contact of the balls with the races. They are generally available in sizes only up to 20 mm diameter.

Double-row angular contacts

The double-row configuration is essentially two single-row angular contact bearings built as a unit, with the internal fit between balls and raceways fixed at assembly time and therefore not dependent upon mounting methods for internal rigidity. The width is standardized and is less than that of two single-row bearings mounted together.

They are made without a filling slot, Fig 8. They are also available with either an externally or internally converging configuration:

Externally converging bearings, Fig 8(A), are the more popular type. Their contact angle converges outside the bearing outer ring to provide a high degree of resistance to misaligning forces.

Internally converging bearings, Fig 8(B), are not as rigid under cocking loads, therefore are used where the desire is

text continued, page 69

BEARING LIFE AND LOAD CAPACITY

Life expectancy

■ When a properly mounted and lubricated ball or roller bearing fails it is usually by fatigue of the material. Fatigue failure, a flaking action, starts as a crack on one of the load-carrying surfaces. Therefore life of a bearing is defined as the number of revolutions (or hours at a given speed) that it runs before first evidence of fatigue develops in any part of the bearing assembly.

At present it is impossible to predict the life of an individual bearing—or even the minimum life that every bearing of a group will equal or exceed. When a number of apparently identical bearings are run under the same conditions of load and speed, there is a dispersion of their life-patterns which varies somewhat with different lots but has the same form.

The "rated life" or, briefly, "life" of a group of bearings is defined by most bearing manufacturers as the number of revolutions that 90% of the bearings will complete or exceed before first evidence of fatigue. The rated life is sometimes referred to as the "L_{10}" or "B_{10}" life.

Life vs load

Tests have shown that for the ordinary range of bearing loads, the fatigue life is proportional to loading as follows:

$$L = \left(\frac{C}{P}\right)^3 \quad \text{for ball bearings}$$

$$L = \left(\frac{C}{P}\right)^{10/3} \quad \text{for roller bearings}$$

where

L = rated life in millions of revolutions

C = basic dynamic load rating. This is the constant radial load which the group of bearings with stationary outer ring can endure for a life of one million revolutions of the inner ring. In a single-row angular contact bearing, the C rating relates to the radial component of that load which, if applied, causes a purely radial displacement of the rings in relation to each other.

P = bearing load, or the equivalent load when the bearing has to carry loads composed of axial as well as radial components.

The numerical value of C in pounds for each ball bearing under consideration is usually given in catalog tables. The rated life of the bearing under an expected load P can be obtained easily from the center scale of the nomograph at right. This chart also helps convert life, in revolutions, to desired combinations of hour-life and speed.

For example, if a radial load $P = 1000$ lb acts on a ball bearing of certain type and bore size, and rated as $C = 2000$ lb, then $C/P = 2$. From the center scale, the bearing has a life of eight million rev. From the outer scales—at 100 rpm, bearing life is approximately 1320 hr; at 200 rpm, life is reduced to 660 hr.

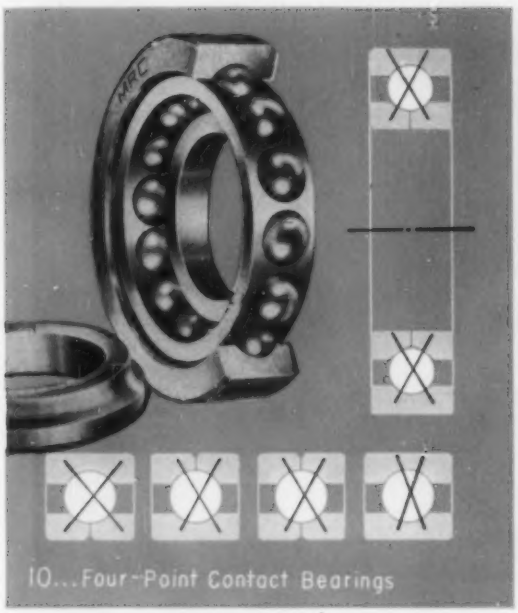
Typical life requirements in hours of operation for different types of application are listed in the table below.

Where the bearing has to carry loads composed of axial as well as radial components, or where the outer ring rotates in relation to the load, one must convert these forces and conditions into an "equivalent load." Most catalogs give equations for this conversion.

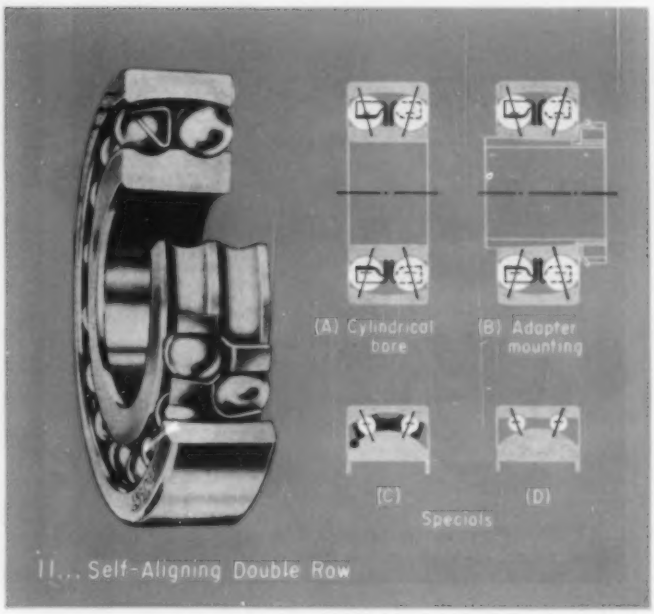
Catalogs also supply the basic "static-load" rating applicable to bearings which do not rotate or oscillate. These bearings are not subject to fatigue, but to permanent deformations or fracture.

REQUIRED LIFE AT CONSTANT OPERATING SPEED
(data from SKF Industries)

Type of machine	Life in hours of operation
Instruments and apparatus which are only infrequently used Ex.: demonstration apparatus; devices for operation of sliding doors	500
Aircraft engines	500–2000
Machines for service of short duration or intermittent operation, where service interruptions are of minor importance Ex.: hand tools; lifting-tackle in machinery shops; hand-driven machines in general; farm machinery; assembly cranes; charging machines; foundry cranes; household machines	4000–8000
Machines for intermittent service where dependable operation is of great importance Ex.: auxiliary machines in power stations; conveying-equipment in production lines; elevators; general-cargo cranes; machine tools less frequently used	8000–12,000
Machines for 8-hour service which are not always fully utilized Ex.: stationary electric motors; gear drives for general purposes	12,000–20,000
Machines for 8-hour service which are fully utilized Ex.: machines in general in the mechanical industries; cranes for continuous service; blowers; jackshafts	20,000–30,000
Machines for continuous operation (24-hour service) Ex.: separators, compressors, pumps, main-line shafting; roller beds and conveyor rollers; mine hoists; stationary electric motors	40,000–60,000
Machines for 24-hour service where dependability is of great importance Ex.: pulp and paper machines; public power-stations; mine pumps; public pumping-stations; machines for continuous service aboard ship	100,000–200,000



10...Four-Point Contact Bearings



11... Self-Aligning Double Row

for somewhat greater ability to operate under moderate misalignment, such as from shaft deflection, and rigid resistance to this is undesirable.

Aside from these characteristics the two types are functionally interchangeable. They are usually made to minus end-play for maximum resistance to deflection under combined loads with thrust from either direction.

Duplex pairs

Two single-row angular contact bearings supplied and used as a unit are called duplex pairs. They can be applied in any of the combinations shown, Fig 9.

The bearings are ground with the ring faces offset from each other a certain predetermined amount. When clamped together, the ring faces are flush and the bearings preloaded according to the original offset. This provides greater axial and radial rigidity, and minimizes deflections under all load conditions.

Back-to-back (DB) mounting: Before mounting, (A), there is clearance between the two adjacent inner-ring faces of the bearings. These faces are clamped together after mounting to provide internal preload.

Select DB pairs:

(1) When loading is cantilevered or overhung as for pulleys and sheaves. Space the bearings apart with equal spacers to obtain highest moment rigidity.

(2) When maximum resistance to misalignment is required.

(3) When shaft tends to run hotter than housing.

Face-to-face (DF) mounting: The clearance here, (B), is between the two adjacent faces of the outer rings. These faces should be clamped together, possibly by means of a housing locknut, as shown. Note also that the inner-ring faces on the opposite side of each bearing are ground as in a DB mounting. Thus, the inner and outer faces are in alignment on both sides.

Select DB pairs:

(1) When alignment cannot be as closely controlled as for DB pairs.

(2) When equal thrust capacity in either direction, as well as radial and axial rigidity, is needed.

(3) When it is desired to dismount spindles, tools and other accessories that are clamped against inner rings—but without relieving the preload of the bearings.

(4) When housing runs hotter than shaft—an unusual case.

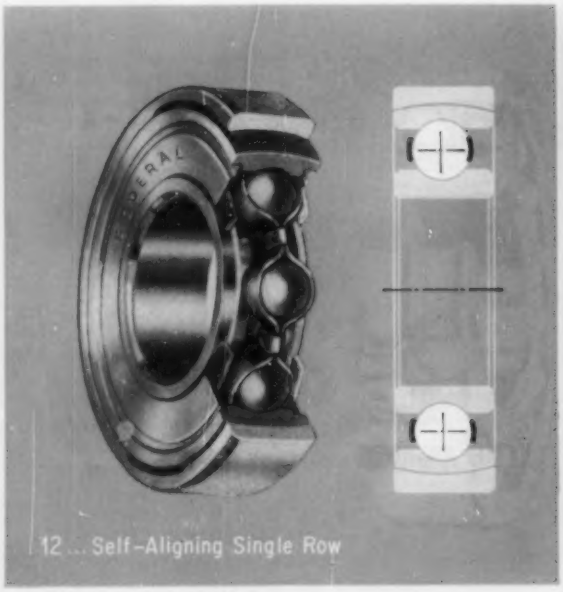
Tandem (DT) mounting: Before mounting (C), inner ring faces are offset from the outer ring faces. Thus, before assembly, both sides of each bearing are not flush. Bearings are mounted in series. After clamping, the inner and outer faces are brought into alignment on both sides.

Select DT pairs: when there are heavy thrust loads from one direction.

Multiple mountings, such as three bearings in tandem, (D), or two tandem DT pairs mounted in back-to-back arrangement, are but two of many variations used in mounting duplex bearings to meet demands of heavily loaded applications.

FOUR-POINT CONTACT BALL BEARING

There is a renewed interest in an old bearing configuration known as the "Gothic-arch" or "four-point contact" bearing, Fig 10. It can carry high thrust in either direc-



12...Self-Aligning Single Row

13...Thin-Race Bearing

tion with good radial-capacity characteristics, so can replace either a double-row angular contact bearing or a duplex pair—and needs less space than either of those.

As its name implies, the bearing has races with cross-sections of slightly pointed (arched) shape. Therefore, the balls contact the races at four points instead of two. It is usually made with a split inner ring to permit entry of a full complement of balls and use of a one-piece machined cage—although it also is made with both rings split, both rings solid, or outer ring split. With the split inner ring, shields are often used to hold the split ring together during shipment and handling since ball retention by the cages is usually impractical because of the high shoulders.

Torque characteristics are complex. Under a small thrust load, one side of the bearing begins to unload and the balls begin to spin, resulting in a high rubbing velocity action at the lightly loaded side. This wiping action can produce a sharp increase in torque. But as the thrust load is increased further, the balls leave the unloaded side entirely and torque characteristics become even better than those of preloaded duplex pairs.

Gothic-arch bearings found their first usefulness in elevator worm drives and later in truck transmissions. Today's refined design is the result of use in aircraft. Recent successful applications include pump motors, torque convertors and actuators. The bearings are often used in pairs.

SELF-ALIGNING BALL BEARINGS

Double-row

Most self-aligning ball bearings are made with two rows of balls rolling on the spherical surface of an outer ring, Fig 11(A). They can compensate for angular misalignment resulting from shaft and housing deflections, and errors in mounting. The balls are free to realign with the outer ring, hence do not exert any bending influence on the shaft. Self-aligning also contributes to smooth running by neutralizing the effect of groove wobble. Thrust capacity is considerably less than for a deep-groove bearing because of the decreased contact area resulting from the large radius of the spherical race. However, the double row of balls give a radial-load capacity almost equal to that of a single-row deep-groove bearing. Self-aligning bearings are usually mounted in pairs.

Most sizes of self-aligning ballbearings are also available with tapered bores for mounting on adapter sleeves (B). This avoids need for shaft machining and is especially suitable for long lineshafting—a major application of the self-aligned bearing.

Self-aligning bearings are sometimes made with spherical inner seats, as in (C), which provides two degrees of freedom, and (D) which can be used at high speeds.

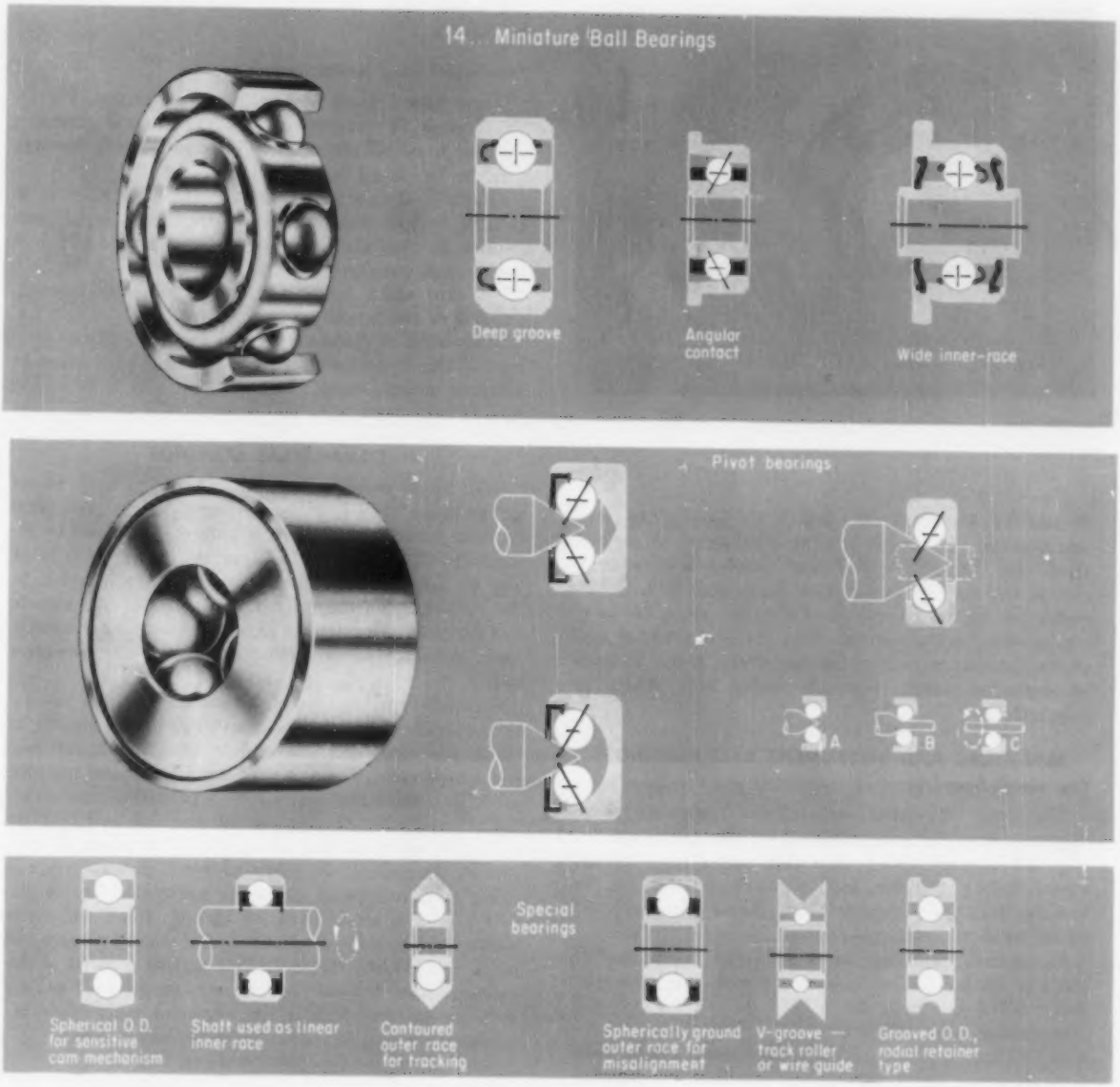
Single-row

Single-row self-aligning bearings are designed to take a combination of misalignment and high-thrust loads, Fig 12. This is accomplished by adding an external, spherically-ground race which aligns on a second outer member whose internal surface is also spherically ground.

THIN-RACE AND RING BEARINGS

Bearings with a very small section in comparison to bore, Fig 13, are successful where weight is a problem.

Exact definition of a thin-race bearing is rather difficult in that there is no sharp dividing line between them and, say, the "extra-light" series. In addition, thin-race bearings are available from 2-in. bore to 150-in. bore—the larger ones are frequently called "ring" bearings.

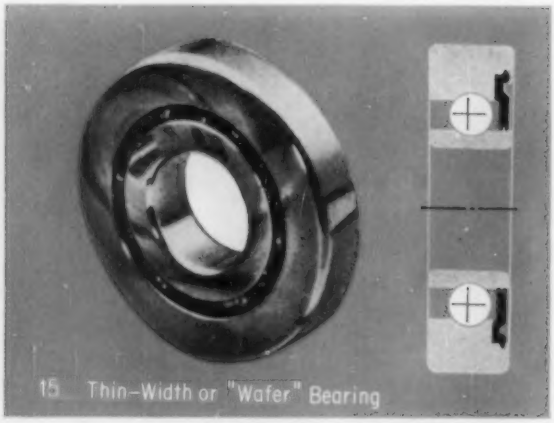


One key difference, however, is that thin-race bearings have very high bore-to-section ratios—the section size being the radial dimensional difference between bore and outside diameter of the bearing. Thin-race bearings are available in bore-to-section size ratio as high as 48:1. Section size of these bearings is from $\frac{1}{4} \times \frac{1}{4}$ in. up to 1 x 1 in. and larger. Bore-to-section size for other types of bearings vary from 3.5:1 for the "extra-light" series to 1.8:1 for the medium series, and even smaller ratios for heavy-duty bearings.

Within the "thin-race bearing" designation there are at least ten general configurations available:

1. Deep-groove Conrad type
2. Deep-groove filling notch
3. Angular contact
4. Gothic-arch ball with solid races
5. Gothic-arch ball with split race
6. Duplex mountings
7. Radial roller
8. Gothic-arch roller
9. Tapered roller
10. Special sections, either on outer or inner rings.

Because of the large ratio between the bore and section size, these bearings offer considerable variations. It might



15 Thin-Width or "Wafer" Bearing

be said that the smaller the ball in the bearing the more sensitive the bearing becomes to interference or preload conditions Fits of the shaft and housing become more critical, also their geometric shape limits must be held. To realize the highest percentage of capacity rating, the bearings must be well supported. Also, the proportion of supporting section to race section becomes a factor in cases of dissimilar metals, especially under wide ranges of temperature.

MINIATURE AND INSTRUMENT BALL BEARINGS

The small bearings

The terms "miniature bearings" and "instrument bearings" are often interchangeable. Both refer to the smaller-size ball bearings. They are made under more critical manufacturing standards, such as cleanliness, than are the bearings discussed previously. Also, they are primarily designed for instrument applications.

In general, "miniature bearings" refers to the smaller series of instrument bearings—those with outer diameter under 0.375 in. (bore size 0.1875 in. and under); and "instrument bearings" denotes an intermediate series—with OD from 0.375 to 1.125 in. (bore size 0.175 to 0.500 in.). However, most catalogs in this field list bearings which overlap both of these series. Basic configurations, Fig 14, include:

- **Deep groove**—flanged and unflanged
- **Angular contact**—separable and unseparable
  —flanged and unflanged
- **Pivot**—angular contact
  —with raceway or spherical seat
- **Wide inner race**

Except for pivot types, the configuration of these bearings has already been discussed. The pivot bearings have a massive section under the balls that enables them to withstand substantial shock loads. They are also for applications with minimum limits of radial and axial play, and are sometimes employed in place of jewel bearings.

The angular-contact types are available as DB, DF and DT duplex pairs, and are also made in many special configurations.

Thin-width and wafer bearings

These have a much heavier (larger) outer ring, Fig 15. But because all components, and the internal geometry, conform to specifications for standard instrument bearings, they can be classed in this category.

Originally designed to permit the rotor of synchros to clear the bore of the housing, they are finding applications in other instruments where axial space is limited and shaft size is small compared with outside diameter of the unit: Their thin width permits through-boring and through-grinding of the housing.

Many sizes of "thin-width" and "wafer" bearings overlap and the terms are employed in a proprietary sense by different manufacturers. Sizes generally vary from 0.0550 to 0.1875-in. bore, with OD from 0.1875 to 0.4375 in.

COMMERCIAL BEARINGS

Most of the bearings already described are usually offered as "precision" ball bearings; they conform to basic plans for boundary dimensions and tolerances established by the AFBMA. "Commercial" ball bearings, on the other hand, Fig 16, are made to tolerances wider than specified by the AFBMA. They usually lack retainers or ball spacers; and the races may be either ground or unground. Recently, some manufacturers are offering them in the miniature sizes.

Generally, applications of commercial bearings call for lighter loads and slower speeds than the maximum at which precision types can operate—for example, automotive components, conveyor rolls, certain business machine parts, household appliances, farm and marine equipment, tractors and toys. Average cost of precision ball bearings is four to six times that of commercial bearings of comparable dimensions. In unground types, the outer race is either machined on an automatic screw machine, or else cold-formed to close limits on presses. Inner and outer races are hardened and tempered. Grinding the inner and outer races doubles the radial-load-carrying capacity of the bearings. Also, because the tolerances on ground types are only one-quarter of those for unground types, they are smoother running and better suited for higher speeds.

Some of the more popular configurations:

- Radial with split outer ring—including single row, single row with flange, and double-row double-split
- Radial with split inner ring (screw-machine radial)
- Radial stud-type for use as a roller
- Combination radial and thrust—including one-piece and two-piece configurations
- Thrust bearings

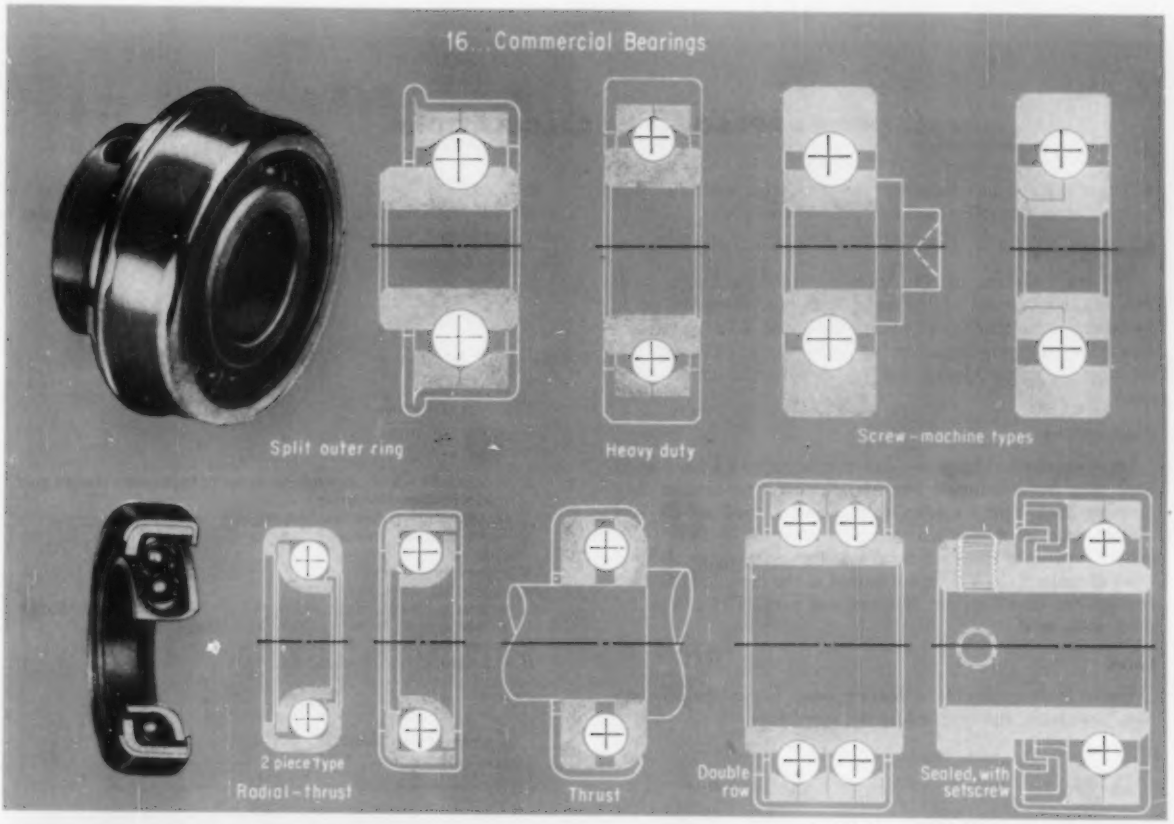
There are also many low-cost "specials" built around these configurations.

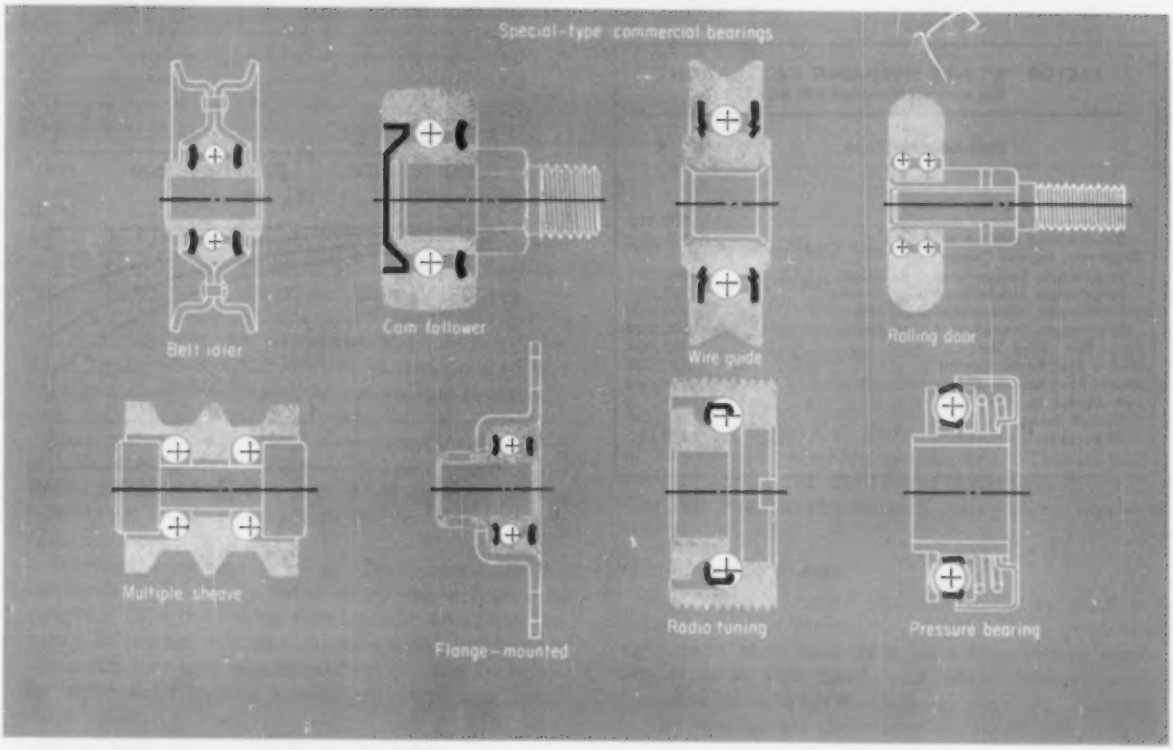
SPECIAL-PURPOSE BEARINGS

Airframe control bearings

Designed to support oscillating control rods in aircraft structures, airframe control bearings are usually the deep-

text continued, page 75


16...Commercial Bearings
Split outer ring
Heavy duty
Screw-machine types
2 piece type
Radial-thrust
Thrust
Double row
Sealed, with setscrew


Special-type commercial bearings
Belt idler
Cam follower
Wire guide
Rolling door
Multiple sheave
Flange-mounted
Radio tuning
Pressure bearing

SPEED-LIMIT CALCULATIONS

■ Three main factors influence the permissible speeds of ball bearings as well as roller bearings:

Bearing size

The larger the bearing, the lower the speed limit. For small and medium bearings of the same type and dimension series, operating under similar conditions, the speed limit is approximately inversely proportional to the bearing bore. For large bearings this no longer applies, and the speed limits are relatively lower.

Proportions

Light-sectioned, deep-groove ball bearings have a higher speed limit than heavy-sectioned bearings of same type because they carry less load, have a smaller mean diameter, smaller balls, and a lighter cage. As a result a more general comparison can be made between speeds of different radial bearings by using the bearing mean diameter d_m as a reference instead of the bore d. For thrust bearings the conditions are different, and here $\sqrt{DH}$ is used instead of d_m or d.

Load

Heavy loads applied to a bearing cause higher temperatures than light loads, and thus reduce the speed limit.

FACTOR "A" FOR SPEED-LIMIT CALCULATION
(for bearings lubricated with oil)

Ball-bearing Type	A
Single-row, deep-groove Conrad	
Ball-centered pressed steel cage	500,000
Ring-centered machine cage	800,000
Single-row, Angular Contact	
Large-angle, ball-centered cage, Single	500,000
Large-angle, ball-centered cage, Duplex	350,000
Small-angle, ring-centered cage, Single	800,000
Small-angle, ring-centered cage, Duplex	600,000
Single Row, Filling Slot	500,000
Double Row, Radial Contact	350,000
Double Row, Angular Contact	350,000
Self-aligning Ball Bearings	
Narrow Series	500,000
Wide Series	450,000

In a report to Navy's Bureau of Ships, SKF Industries recently presented the following equations based on the factors and on a speed-limit factor A:

For radial bearings

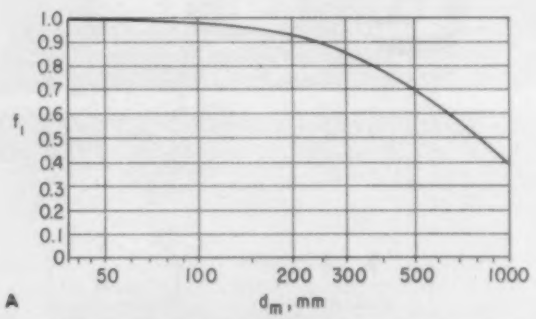
$$n = \frac{f_1 f_2 A}{d_m}$$

For thrust bearings

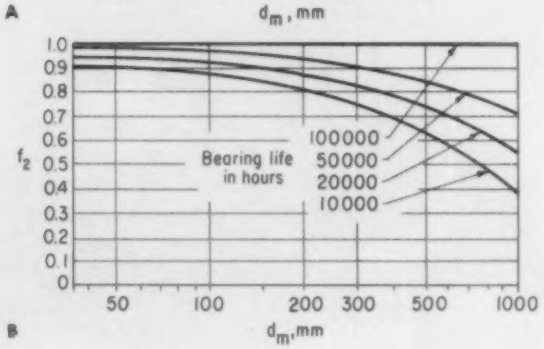
$$n = \frac{f_1 f_2 A}{\sqrt{DH}}$$

where

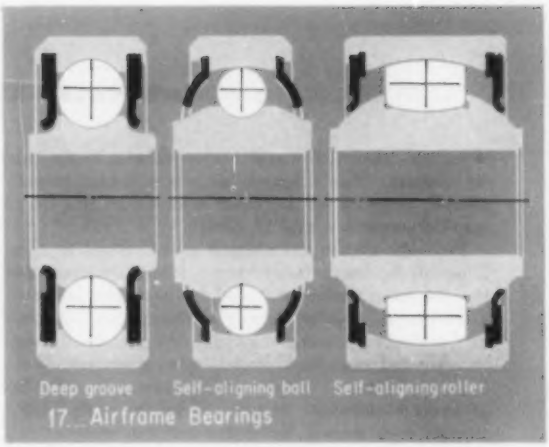
- A = constant which depends on bearing type, cage design and lubrication (see table)
- f_1 = correction factor for bearing size—see curve (A)
- f_2 = correction factor for bearing load—see curves (B); for moderate loads use $f_2 = 1$.
- n = speed limit, rpm
- d = bearing bore, mm
- d_m = bearing mean diameter = 0.5 $(d + D)$, mm. For needle bearings d_m = pitch dia of the needle rollers
- D = bearing outside diameter, mm
- H = height of thrust bearing, mm



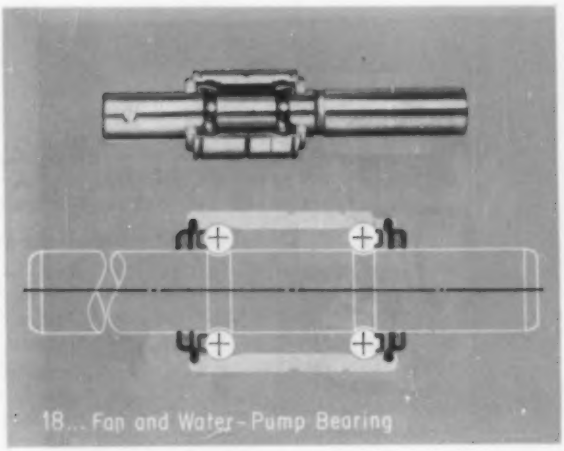
A

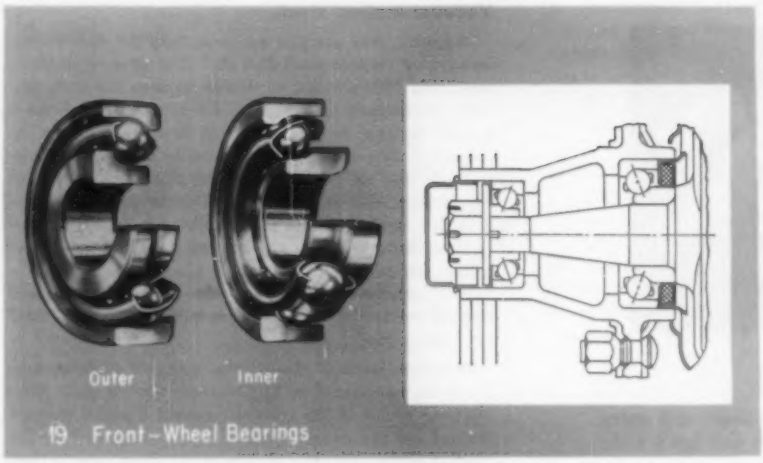


B



17... Airframe Bearings


18... Fan and Water-Pump Bearing



19... Front-Wheel Bearings

groove or self-aligning type, Fig 17. They offer high reliability under heavy-duty operation—but are restricted to oscillating applications or speeds under 600 rpm.

They are produced to the high standards of MIL-B-7949 which requires rigorous inspection for cracks and flows. They are cadmium-plated or made of stainless steel, and contain contact seals to exclude dirt and salt-water moisture, and to retain a grease lubricant.

Deep-groove type. Contains absolute maximum number of balls by employing a filling notch and eliminating the ball retainer. This gives a high radial capacity—but the lack of ball spacer produce high friction which restricts operating speeds.

Self-aligning airframe bearings. These compensate for misalignment caused by initial set-up and deflection in structure. The ball-bearing type can take ±10° misalignment—in contrast with standard self-aligning ball bearings which can take only approximately ±2°. Also available—for higher radial loads—is a self-aligning type with barrel-shape rollers.

Fan and water-pump bearings

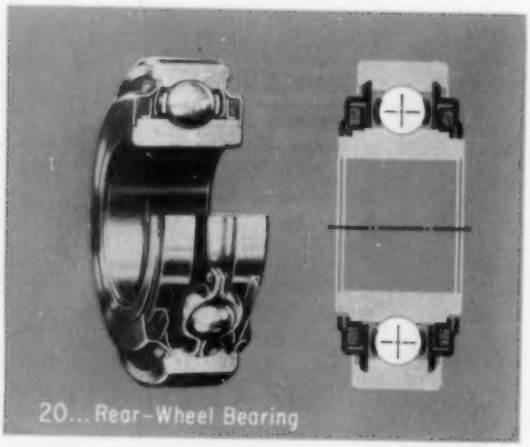
These are especially designed to simplify the mounting of automotive fan and water pump, Fig. 18, but their compactness make them suitable for applications where space requirements prevent using two single-row bearings. Applications are in arbors, drill presses, belt idlers and spindles.

The accurately ground shaft has raceways for two rows of balls, avoiding need for an inner race. This keeps the outside diameter of the bearing correspondingly small. The unit is sealed at both ends, permitting a supply of control lubricant.

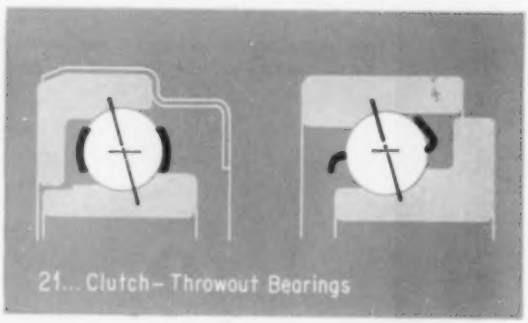
Front-wheel bearings

This type is designed especially for heavy radial and thrust loads. The bearings are frequently used in cars and light trucks where loads are imposed when turning corners sharply or at high speeds, and where there are severe pounding or vibratory loads.

The bearings are of the angular contact type, Fig 19,



20... Rear-Wheel Bearing



21... Clutch-Throwout Bearings

and made in pair for application to the inner and outer front-wheel positions. The larger of each pair has a wide or extended inner ring to furnish a smoothly ground surface for the felt seal customarily employed.

They are separable, thus facilitating assembly or removal of the wheels from the spindles. Because the outer rings rotate, they are press-fit in the hubs and the inner rings are an easy push fit.

Front-wheel bearings are set up in the correct running adjustment by means of a nut on the end of the spindle and in this way are so opposed, with balls and races in firm angular contact, that the wheels are securely held against combined loads with thrust from either direction.

Rear-wheel bearings

Single-row, double felt-seal types, Fig 20, are for automotive rear-wheel applications. They permit using a single bearing for locating each axle shaft.

The bearings are a permanently sealed unit, closed on each side by an efficient felt seal and packed with grease during assembly. They are finding wider applications.

Angular-contact clutch throwout

Designed for rugged load and mounting conditions peculiar to automotive clutch service, they are available

text continued, page 78

THE MATERIALS

■ Fatigue failure is the most severe challenge to the bearing designer. This is because wear in a bearing properly selected, mounted and lubricated is so minute that for all practical purposes it may be ignored.

Yet, with all the technological advancements in other fields, the bearing industry has yet to find materials that give the fatigue reliability called for in today's products. Some bearing manufacturers claim that the steel industry isn't researching enough—that this lack of interest stems from the fact that the bearing industry is not one of the large users of steel. Other manufacturers point out that government-sponsored research is lagging. Meanwhile, pressure from users is buildingup and the manufacturers feel caught in the middle.

Vacuum-melted steels

However, some progress has come from the recent development of vacuum-melted steels. The process produces steel to a higher order of cleanliness than formerly possible. Endurance tests and service experience indicate a general increase in life, and most bearings can now be ordered in this steel. Though these vacuum-melted varieties may cost up to 10 times more than their air-melted counterparts, cost of the bearing does not go up anywhere near that much. But, although there has been a general increase in bearing life, the dispersion pattern of fatigue failures has not been improved.

The induction method and the consumable-electrode method are two types of vacuum melting commercialized for bearing steel.

Induction method changes the required elements into a crucible surrounded by an induction heating coil. After pumping air out of the chamber, current is passed through the coil and the charge is melted. Time is allowed for the gases to escape from the molten metal; the charge is then poured into ingot molds. Vacuum is maintained until the steel solidifies.

Consumable-electrode process has a heat steel of desired analysis first produced by air-melting. After the molten steel has solidified it is used as electrodes for remelting under vacuum. The electrode is placed in the chamber, which is then evacuated. An arc is struck between the bottom of the electrode and some material (of same analysis as the electrode) placed in the bottom of an ingot mold made of copper. Heat of the arc slowly and progressively melts the electrode and builds up the ingot in the mold.

In a report to the Bureau of Ships, SKF Industries points out that the consumable-electrode process is producing bearing steel of a more consistently high level of cleanliness than the induction method, and at lower cost. Consumable steels cost about $1 more per pound than for the

THAT ARE NEEDED IN BEARINGS

same product air-melted, while the induction steels cost about $2 more per pound.

52100 medium-chrome steel

Most bearing rings (except instrument bearings) are made of high-carbon medium-chrome steel (see chart for typical composition). Although other steel analyses have been tried, no commercially melted analysis has consistently given better fatigue resistance than the 52100.

The rings are usually through-hardened and oil-quenched, and then tempered by reheating to a range of 225 F to 500 F. Approximate temperature limitation of this material ranges from 300 F to 400 F (see chart). The balls are frequently made of 51100 steel which has a lower chromium content.

Stainless steels

Usually of the 440 C or 440 F types, the stainless steels offer good corrosion resistance, with fair life at elevated temperatures. They are widely used, and the 440 F, which is a free-machining grade, is becoming first choice for instrument bearings where loading is not critical.

COMPOSITION OF BEARING STEELS

Alloy type	Percentage of elements									
	C	Mn	Si	Cr	W	V	Mo	Co	Ni	Cu
52100	1.05	0.35	0.30	1.45	—	—	0.06	—	0.25	0.25
440C	1.10	0.55	0.50	18.00	—	—	—	—	—	—
M1	0.80	0.30	0.30	4.12	1.50	1.10	8.50	—	—	—
M2	0.85	0.30	0.30	4.12	6.00	2.00	5.00	—	—	—
M10	0.88	0.30	0.30	4.12	1.00	2.00	8.12	—	—	—
M50	0.81	0.30	0.30	4.12	0.25	1.00	4.25	—	—	—
T1	0.70	0.30	0.30	4.12	18.25	1.15	—	—	—	—
T6	0.80	0.30	0.30	4.60	20.00	1.80	0.85	12.00	—	—

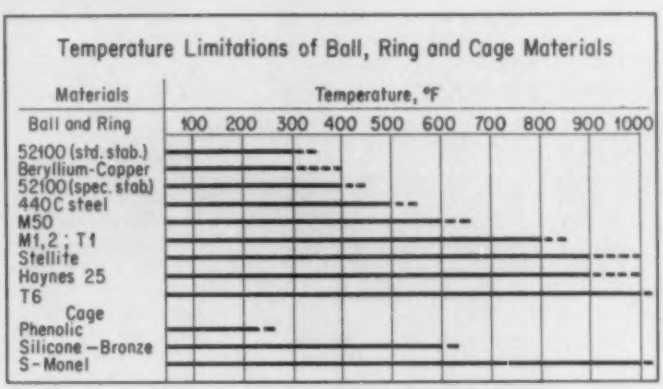
High-temperature materials

Tool steels. The steels in this category employed for bearings are: M50, suitable to at least 600 F; M1, M2, M10 and T1, suitable to at least 800 F; and T6, now under development and may be suitable to 1000 F and over.

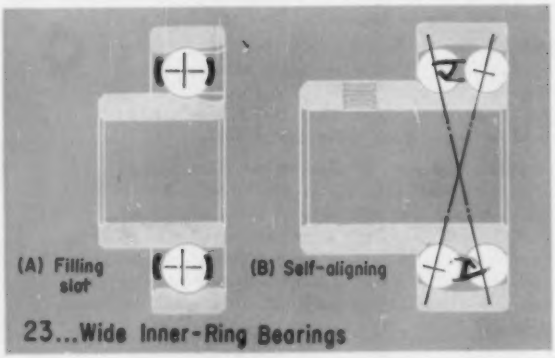
Stellites and Haynes 25. Most steels oxidize and develop scale at temperatures of 800 F and above unless protected by coatings or special atmosphere. Alloys such as Stellite or Haynes 25 give good service above 900 F, even though hardness of some falls short of the desired 58R_c.

Nonmagnetic materials. Beryllium-copper alloys, such as Berylco 25, have been successful in applications where a nonmagnetic bearing is needed. Here, all components must be made of this material. These alloys have excellent resistance to atmospheric corrosion and are particularly resistant to hot or cold dilute sulfuric acid, alkaline solutions and petroleum products. Bearings made of Berylco can be operated to 350 F.

Cage Materials. These are usually a compromise between weight, friction properties and strength. Phenolic separators are subject to high-temperature charring, but have excellent friction and weight properties. Silicon-iron bronze (AMS4616) has proven satisfactory to 600 F, and S-Monel, coated or plated for low friction, has good strength to 1000 F. ■



22... Adapter Bearing



23...Wide Inner-Ring Bearings

in several series having certain exterior differences in design to suit various kinds of clutches, Fig 21.

These bearings are made with the correct angle of contact to operate efficiently under full-thrust loads, but are nonseparable and will not loosen and rattle when the thrust load is released. The bearings, quiet and smooth-running under thrust, are not adversely affected by centrifugal force.

Adapter bearings

This bearing is similar to a single-row, Conrad shielded bearing, but with an extended inner ring and collar. Two setscrews, Fig 22, engage the shaft-through holes drilled in the extended inner ring. This allows securing the unit to the shaft without distorting the bearing inner ring.

Outer surface of the bearing is cylindrical, or spherical (as shown) for easy mounting in pillow blocks and stamped flanges. The bearing is only for applications where loads and speeds are moderate and alignment and concentricity are not critical; it is not recommended where the shaft oscillates.

Wide inner ring bearings

These bearings have the same bores, outside diameters, and outer ring widths as the Conrad types, with or without filling slot, as shown in (A), or the self-aligning types (B), Fig 23. The extended inner ring permits the bearing to be fastened on the shaft with less of a press fit, thus avoiding need for a lock nut. The inner ring is also available with setscrews.

WRITE HERE FOR CATALOGS

Numbers refer to ball bearings illustrated in the text. Only catalog items are listed here. These manufacturers may make a wider variety of type upon request than those they list in their catalogs.

Aetna Ball and Roller Bearing Co, Chicago Ill—*21, 22*

Andrews Bearing Co, Spartanburg, SC—*16*

Ann Arbor Bearing & Mfg Co, Ann Arbor, Mich—*13*

Barden Corp, Danbury, Conn—*1, 5, 6, 7, 9, 14*

Bearings Company of America, Lancaster, Penna—*1, 3, 5, 8(B), 16, 19, 20, 21, 22*

Browning Mfg Co, Maysville, Ky—*22*

Fafnir Bearing Co, New Britain, Conn—*1, 3, 5, 8(A), 8(B), 9, 11(A), 12, 14, 17*

Federal Bearing Co, Poughkeepsie, NY—*1, 2, 3, 5, 7, 8(B), 11(A), 12, 18, 19, 20, 21, 22, 23*

Freeway Washer & Stamping Co, Cleveland—*16*

General Bearing Co, Mineola, NY—*16*

Hartford Steel Ball Co, Hartford, Conn—*16*

The Heim Company, Fairfield, Conn—*1*

Hoover Ball & Bearing Co, Ann Arbor, Mich—*1, 3, 8(A), 18, 22, 23*

Industrial Tectonics Inc, Ann Arbor, Mich—*1, 3, 5, 8(A), 10, 11(C), 11(D), 13*

The Kaydon Engineering Corp, Muskegon, Mich—*13*

Landis & Gyr, New York City—*14, 16*

Marlin-Rockwell Corp, Jamestown, NY—*1, 2, 3, 5, 8(B), 9, 10, 14, 17, 18, 22, 23*

Messinger Bearings Inc, Philadelphia—*13*

Microtech Corp, El Monte, Cal—*14*

Miniature Precision Bearings Inc, Keene, NH—*14, 15*

Mono-race Div Thew-Shovel Co, Lorain, Ohio—*13*

New Departure Div, Gen. Motors Corp, Bristol Conn—*1, 3, 5, 6, 7, 8(A), 8(B), 9, 10, 14, 18, 19, 20, 21, 22, 23*

New Hampshire Ball Bearings Inc, Peterborough, NH—*14, 15*

Nice Ball Bearing Co, Philadelphia—*1, 16, 23*

Norma-Hoffman Bearings Corp, Stamford, Conn—*1, 3, 5, 7, 8(A), 9, 11(A), 17*

Schatz Manufacturing Co, Poughkeepsie, NY—*16*

SKF Industries Inc, Philadelphia—*1, 2, 3, 5, 8(A), 9, 11(A), 22, 23*

Split Ballbearing, Div of MPB, Lebanon, NH—*4, 13*

The Torrington Company, South Bend, Ind—*1, 3*

REPRINT COPIES of this report are available for 50 cents by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, N. Y.

PHOTO CREDITS: Federal—*Fig 12;* Hoover—*Fig 3;* Kaydon—*Fig 13;* MRC—*Fig 1, 10, 18;* MPB—*Fig 14, 15;* New Departure—*Fig 7, 8, 19, 20, 22;* Nice—*Fig 16 (middle);* Schatz—*Fig 16 (top);* SKF—*Fig 5, 11;* Split Ballbearings—*Fig 4;* Fafnir—*Fig 9*

EDITOR'S NOTE—For more information on ball-bearing types, tests, lubricants and failures see:

Integral Ballbearings—New approach to Product Improvement, Apr 25 '60, p47—Inner or outer race incorporated as an integral part of the product.

Sealed Ballbearings—Which Type? Feb 29 '60, p 54--Covers all types of integrally sealed and shielded.

These Methods Test Performance of Ballbearings, Sep 14 '60, p 78—Special and commercial devices to check bearings for torque, vibration and runout.

How to Measure Preload and Play in Ballbearings, Sep 28 '60, p 41—Round-up devices for these factors.

Guide to Lubricants for Instrument Ball Bearings, June 9 '58, p 66—Covers 42 types of oils and greases.

Why Bearings Fail, Oct '56, p 167—Analysis of most common causes of sliding and rolling bearing failure.

CREATIVITY . . . a new appraisal

"CREATIVITY — the Facts Behind the Fad" *(PE—Aug 24 '59)* stimulated a number of letters and other contributions. Here are extracts and ideas from hitherto unpublished sources, shedding further light on the twin problems of industry vs the creative man, and a conservative society that seeks for innovation.

E J TANGERMAN
Chief editor

Smiles needed, not IQ

Correlation between high IQ and high creativity has always been assumed. So it has been assumed also that the "gifted child" should be found and encouraged. Now, however, two educational psychologists at the University of Chicago, Jacob W. Getzels and Philip W. Jackson, after four years of experiments supported by the US Office of Education, have concluded that **neither the IQ test nor teacher preference is a completely dependable means of identifying students of high potential.** After study of the top 20% of two types of students in a sample of 500, the "highly intelligent" and the "highly creative" (but not those who were high in both—now being studied further), the two psychologists conclude:

1. **Emphasis on sense of humor is so marked among the creative group that it sets them sharply apart.**

2. **High-IQ children seek now the qualities that they believe mean adult success. Creative children are not impressed by this goal.**

3. **High-IQ children hew to a self-ideal they feel that teachers will approve. The creative child does not.**

In simple terms, the high-IQ children tend to be conventional, to seek success in the standard known way, while the highly creative children diverge from the stereotype, seek to integrate fantasy and reality, enjoy the risk of seeking success through the unknown.

A new creativity theory

Max Beery of Seattle has developed a creative theory in this direction. He makes two premises:

1. **There is no real correlation between intelligence and creativity.** The apparent correlation is caused by the fact that the higher the intelligence at a given creativity level, the more outstanding the results of that creativity. This phenomenon is accentuated by the tendency of the ability to communicate to be proportional to intelligence. Thus a difficult scientific or engineering problem may be solved by a creative person without the "necessary" background. Because he cannot prove his solution to the "experts" (predisposed against him) it is likely to be ignored.

2. Knowledge is passed on from one generation to the next by three methods: inheritance of specific behavior patterns, training of the young, or through inheritance of a general behavior pattern or instinct to mimic the existing cultural pattern (tradition). The first is almost impossible to change because it is so complex and requires mutations for changes. The second depends on the knowledge and ability of the elder to teach and the younger to learn, but behavior changes can occur without genetic changes—cultural evolution is possible.

The third is our method, and seemingly an evolutionary improvement that is very efficient. Genetically speaking, it is relatively young. Man made, for nearly a million years, the same crude hand axes and flakes of stone. Then a mutation occurred near the end of the Pleistocene Age, and in the early part of the Mesolithic Age (a short 15,000 years ago) a cultural flare-up occurred that is still accelerating. The assumption here is that tradition covers much more than old-school ties and Easter lilies—even every act and most thinking patterns. Logic is normally powerless against tradition, but some churches, lodges and philosophies have unwittingly developed tradition-building techniques—have seemed to develop a little tradition control. **Mr Beery feels that if a nation could learn to stop, start and control traditional behavior functions, it could rule the world.**

A definition of creativity

Based on these two premises, Mr Beery provides this definition: **"Creativity in the individual, regardless of intelligence, is a result of the lack of the normal instinct to mimic existing cultural patterns."** If this is true, it explains the behavior differences of creative people and why we haven't been able to devise a test for locating them. **We have been looking for the presence of something that does not exist instead of looking for the absence of something that does exist.** Psychology should be able to measure the strength of the instinct to mimic.

"Innovator" sounds better

In a recent study, A D Little Inc found it essential to avoid the word "inventor" with its connotations of

cellar shop, slight madness and no formal training. No matter how carefully their researchers defined "invention" and "inventor" as possibly producible in large organizations, everybody concerned had the same mental block—the picture conjured by the word. "Innovator" and "innovation" proved to be safer semantically.

The individual innovator (or inventor) is certainly not extinct, despite much written and spoken commentary to the contrary. National Inventors Council in a recent study showed that half or more of inventions during the past half century are the result of individual spark. Even though the final form may be contributed to by many people, the originator is an individual, single-minded, practically willing to martyr himself in order to get his ideas looked at—all this in spite of agencies supposedly knocking themselves out trying to keep the doors open to innovators.

Organizations need a defense against innovators. They set up systems to keep out ideas, simply because the organization would dissolve in chaos if all suggested—and good—changes were made. **This is true both of government and of industry; they resist ideas while begging for them.** Screening groups within the government have become so effective that not one idea from an outside individual has been accepted within the past 10 years. Several inventors (whoops!—innovators) have written me of their failure to get a hearing with new ideas for industry—even when the company in question has been built on an offbeat idea within the past few years. Apparently, the wall against outside ideas is built very quickly, and often unknowingly.

Needed: a martyr

Even within an organization, it is hard to get a hearing for ideas. The martyrdom—either on the part of the innovator or on the part of a dedicated sponsor (i.e., Admiral Rickover) is essential. Also necessary are that the problem be assigned to a specific individual, that active support and followup are added once the solution has been reached, and that an informal system of communication and control supplement or replace the usual formal system.

In the usual instance, the innovator or his sponsor needs the help of an Archimedes—a place outside the "world" on which to stand and get added leverage. The footrest can be Congress or the President in the case of government, or the public in the case of a company. If enough leverage can be applied through these, the idea has at least a chance of being considered, with some likelihood of acceptance.

Creative man is an artist

Ted W. Birk, engineering designer for the past 25 years, is a native German who has been in the US since 1947. He was startled to find he had to relearn his trade when he came here because of the great differences in customs and conditions. He has been even more startled at the paradoxical situation in which conservative management attempts to make creative men conform to its employe pattern without damaging their creativity, and in which creative men must fight even to obtain a disinterested hearing for new ideas.

Says he: "The problem seems to be that neither side has the right approach. Industry looks upon the creative engineer or inventor as if he were a strange animal which nevertheless can be bought on the open market in accordance with a checklist or a test program. Then this person must be broken in to become just another member of the technical staff without losing his creativity. The creative inventor, on the other hand, considers management as saturated with conservatism, egotism, prejudice or plain shortsightedness. He withdraws from company-directed development work and starts out on his own despite the financial risk tied in with independence."

What is creativity?

"In spite of the fact that misuse of the word 'creativity' has made it difficult to come up with an exact definition," Mr Birk goes on, "I will settle for the short and simple version: **The ability to produce repeatedly new results with new means.** This obviously disqualifies the one-shot inventor, who by sheer coincidence stumbled on a solution, as well as the professional researcher, who gambles for a new discovery in a trial-and-error roulette of innumerable repetitions of basically the same approach of a specific problem. Luck or perseverance can come in quite handy at times, but the two together can never replace creativity. This rare talent is the only available force to bring about a breakthrough or even smash-through so desperately needed in many fields for the increase of foreign-market penetration and employment here at home.

"A man with a talent is an artist, no matter how actively or passively he uses his ability, and no matter to which art his talent is related. The composer, the painter, the actor or the creative inventor (distinguished from the one-shot gadgeteer) are artists and well aware of their aptitude. True artists are always ready to work hard and to sacrifice for the superhuman satisfaction which only creative effort can produce. Nothing else can make man feel the exalted job of achievement and the crushing pain of seemingly unjust defeat, experiences which otherwise are known only to the gods."

Mr Birk lists as obstacles the familiar belief that all creative individuals are crackpots and nonconformists, and the **resistance of a company engineering department to new ideas.** He adds, however, another one:

Custom-tailored inventions

"Another solution could be found," says Mr Birk, "if tor is limited to a certain engineering field, a particular concept, or worse, to the specific design he may have presented. This is a costly misconception; Management and Engineering should realize that usually our inventor has many variations of his design considered for special applications and can easily provide more suggestions. Suppose a company with considerable interest in the general field of an innovation comes to the conclusion that the presented design is too complicated, too large in scope or too advanced for customer demand; it may require staff increases or new machinery or other changes of the present setup. It should not, however, reject before interviewing the innovator for desirable adaptations. Here a discussion with the inventor can make him adjust his proposal to your requirements. He will custom-tailor his design to specifications or he is NOT a creative inventor.

"Another solution could be found," says Mr Birk, "if a number of creative engineers and inventors would unite in an active Society of Engineering Designers. This society should differ from a club or professional association insofar as it would do business for its members and

by its members in patent development, patent promotion and patent exploitation. Here people of the same kind, knowing how to stimulate creative thinking, always ready for new engineering challenges and unrestricted by company-related seniority problems, could become the nucleus of a technological avant-garde to solve breakthrough assignments in an atmosphere of independence and in a frame of competitive cooperation. Thus the creative student, the independent engineer, the chemist, the physicist, the experienced technician—in short, true creative innovators in the 'lone inventor' group, providing this country with 60% of its most important patents—could unite to improve and accelerate technological progress.

Other Birk ideas

In many cases "creativity" has been linked with a youthful age group. This, without hesitation, can be called pure assumption. Two factors are needed to actuate creativity; first and basically the "talent," and secondly the "environmental condition." The younger man with the talent can take the chance with a creative failure, the older one with greater sense of responsibility cannot. Relieved from such personal risk, the retired engineer who originally had the talent, again becomes a productive innovator. (See Maurice G. Steele's letter, *PE—Feb 8 '60, p 29*).

Ray Borst (*PE—July 18 '60, p 24*) discards everyone over 40 as too senile for creativity, completely ignoring that he himself has not much more than 10 years left to demonstrate creativity if his assumption would be true. And 10 years is a minutely short time for any great and valuable innovation to be conceived, created, developed and made available. However, his suggestion of a conference of creative engineers or inventors to deliver engineering breakthroughs for industry should be acceptable.

The breakthrough society

The objective of a coalition between creative inventors or engineering designers is formation of an active business association for the improvement of their creative contributions and betterment of their relation to industry. Such a breakthrough society should provide for its members these services:

1. To unite creative inventors in a professional organization with the task to assist its members in patent design work, industrial problem solution, pioneer technology and the business of selling the resulting patent rights to interested manufacturers in license or assignment agreements on a commission base.

2. To provide for the creative members a panel of professional critics to evaluate new proposals on a merit/request ratio, thus directing the member's efforts toward a more practical solution to his project.

3. To provide facilities and/or funds for model work and prime R & D, as well as a feedback program in which companies state their needs while a member group prepares and presents a number of solutions for selection.

4. To promote patent-law modernization for increased protection of inventor, licensee and assignee.

Now available, a combined reprint on CREATIVITY

How you measure, test and encourage creative engineers. Combined in a single 36-page booklet

. . . **Creativity—the facts behind the fad**
A summary of current thinking on this controversial subject.

. . . **Can you spot a creative engineer?**
Checklist of unusual attributes of creative people.

. . . **How good are engineering aptitude tests?**
Advantages and limitations of ability tests and other psychological exams.

. . . **Interviewing engineering-job applicants**
Preplanned interviews can give clear indications of engineering ability.

. . . **Are you creative?**
A psychologist lists traits, both social and personal, of creative people.

. . . **Are creativity tests helpful?**
Author claims tests are ineffective—sometimes downright harmful.

. . . **Creativity tests ARE helpful**
A rebuttal by the test designers.

. . . **Individual invention—a lost art**
Is large-scale industrial research blinding us to our most valuable resource?

. . . **Lone invention—no lost art**
Cooperation IS possible without sacrificing originality or independence.

. . . **Research management—a problem in personalities**
Research personality types and the incentives that appeal to them.

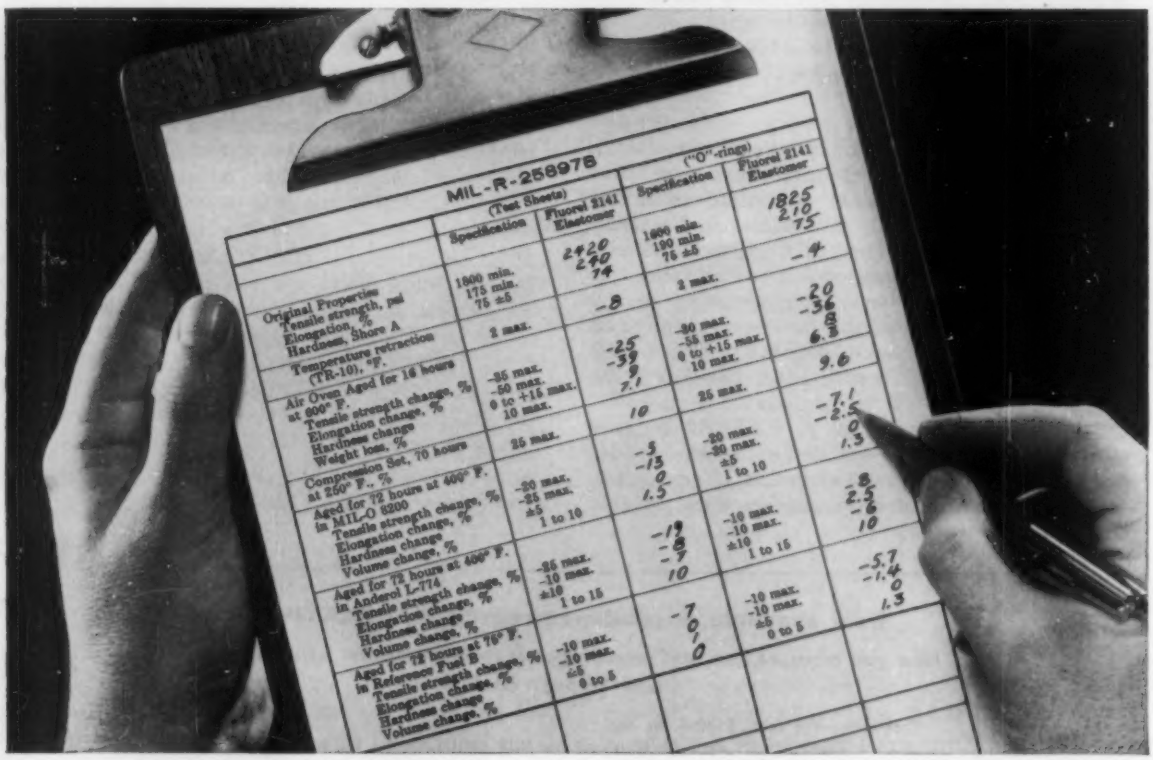
Copies of this combined reprint are available at $1 each, including postage. Send order with remittance to:
Reader Service Dept, Product Engineering, 330 W 42nd St, New York 36

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS

NEW FLUOREL® 2141

BRAND ELASTOMER



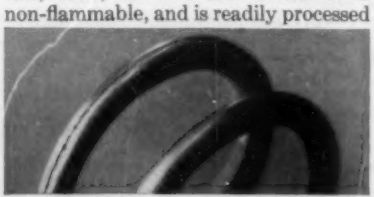
Compare FLUOREL 2141 Elastomer compound with MIL-R-25897B—Specifications above.

MIL-R-25897B quality—now available in quantity

Compounders throughout the U.S. can now supply all your needs for a maximum quality compound according to "MIL-specs" with new FLUOREL 2141 Brand Elastomer.

This new elastomer—because of its outstanding Mooney Scorch Rating, plus other qualities—provides the solution for applications where high temperatures and corrosive media prevail . . . gives you the extra margin of safety available only from a compound that can meet military specifications. Rated for continuous service at 400°F, it can withstand 600°F. temperatures, and higher, for reduced periods of time under certain service conditions.

FLUOREL 2141 Elastomer provides excellent resistance to corrosive chemicals, fuels, solvents and ozone. It is non-flammable, and is readily processed on standard rubber compounding and fabricating equipment. It may be molded, extruded and bonded to most metals . . . is finding broad application in aircraft, missile, automotive and chemical industries.



FLUOREL 2141 "O" ring, bottom, is free from defects of elastomer "O" ring, top.

Examine your present elastomeric and/or rubber products with an eye toward improving their quality and performance through use of new FLUOREL 2141 Elastomer. Specify this new elastomer to your compounder. For complete data, write to: 3M, Chemical Division, Dept. KAS-120, St. Paul 6, Minnesota.

®"FLUOREL" is a reg. T.M. of 3M Co.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

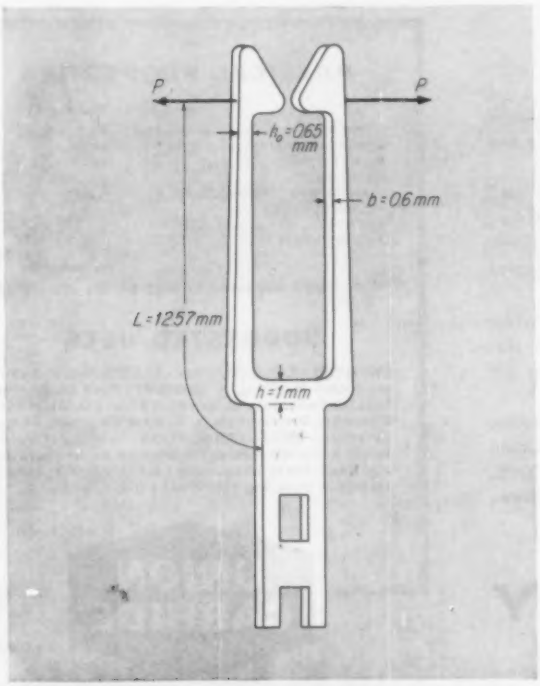
EASIER WAY TO FIND TRAPEZOIDAL-SPRING DEFLECTION

For calculation purposes, it "converts" the trapezoidal to a constant-thickness spring. This digest is from a German article by Joachim Palm in the magazine *VDI-Zeitschrift*, No. 34, Dec '59.

It is often desirable to profit from the design advantages offered by trapezoidal springs. But there is a drawback—deflection of the trapezoidal type is harder to calculate because of its shape. This, however, can be overcome by using a correction factor for deflection; it makes the calculating methods the same as for a spring with constant cross-section, but you are designing a trapezoidal spring. This allows you to take advantage of the trapezoidal configuration, which gives greater deflection for the same strength; and, conversely, greater strength for the same deflection.

Because it's less likely to break, the trapezoidal spring is often used for critical-contact applications. Its ma-

continued on page 85



SYMBOLS

b = Width of spring, mm

E = Modulus of elasticity, kg/mm²

f = Spring deflection, mm

h = Thickness of spring at restrained end, mm

h_O = Thickness of spring at free end, mm

I = Moment of inertia, mm⁴

K = Correction factor

L = Length of spring, mm

P = Load on spring, kg

β = Thickness parameter

λ = Spring stress from bending, kg/mm²

All formulas work equally well with English units.

LINDE 99.9% Pure ALUMINA ABRASIVES

'BULOVA' WATCH PINIONS (sample shown magnified 100x) now have important surfaces polished to a high precision finish with LINDE alumina abrasives. Actual size is at right

Permit Critical Finishing of ALL Modern Metals with ONE BASIC MATERIAL

No longer need the minuteness of a metal part, or its shape, or its type of metal interfere with the quality of its finish.

All-new LINDE abrasive powders—of 99.9% pure alumina—now permit precision finishing and polishing, as well as sharpening and honing of many metal parts—with *one basic material.*

Depending upon usage, LINDE alumina powders can be used dry, mixed with water or other vehicles to make a thin slurry or heavy paste, or compounded with waxes in convenient stick form. They are uniform in size, thus eliminating levigation in finishing operations. And they are resistant to common acids.

Only two grades of these low-cost, fast-cutting, high-purity white powders are required: LINDE A (*alpha alumina*) for quicker cutting and an unsmeared finish; LINDE B (*gamma alumina*) for somewhat slower cutting but an extremely fine finish.

For details on alumina abrasives as applied to your production problems, write Dept. PG-121, Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York. *In Canada:* Union Carbide Canada Limited, Linde Gases Division, Toronto 12.

PHYSICAL PROPERTIES

	Type A-5175	Type B-5125
Chemical Formula	Al_2O_3(Alpha)	Al_2O_3(Gamma)
Crystal System	Hexagonal	Cubic
Hardness, Mohs'	9	8
Particle Size approximate (microns)	0.3*	<0.1
Apparent Density (g/c.c.)	0.3-0.6	0.2-0.5
Melting Point	2050° C.	Transforms to Alpha form at high temperatures

*Type C-5250 also available in 1.0 microns (approximate) particle size.

SUGGESTED USES

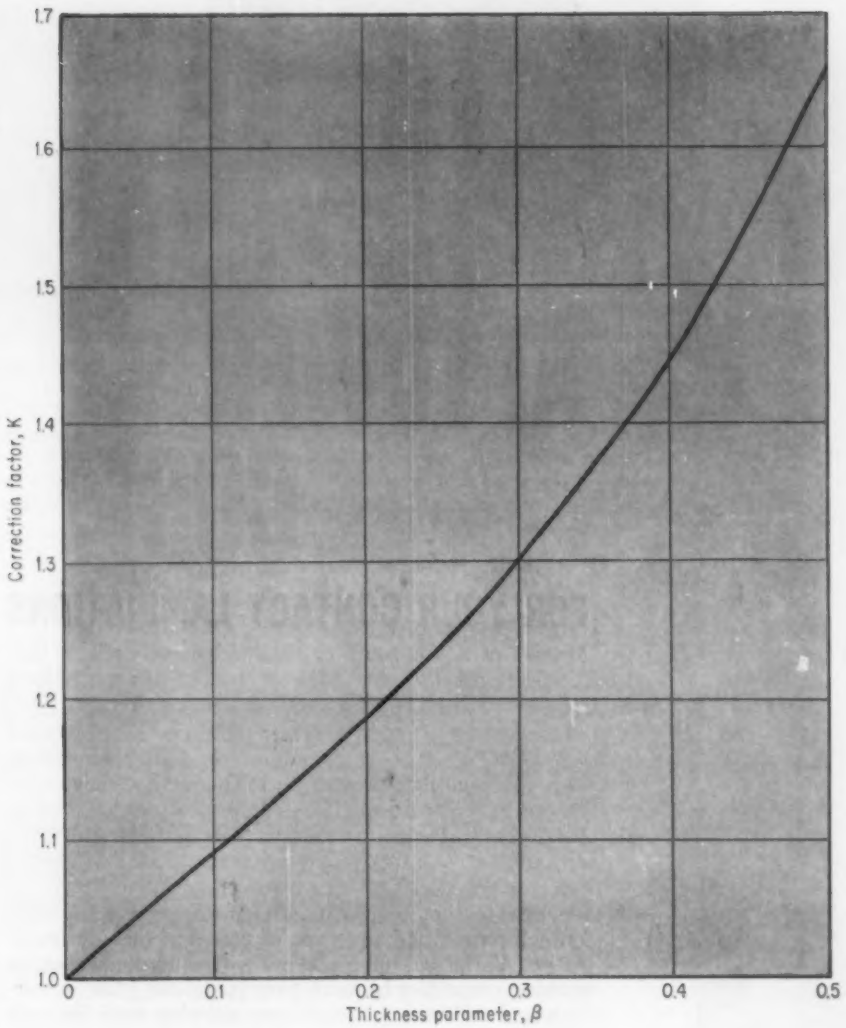
CHEMICAL: Catalyst Carrier • **ELECTRONICS:** Semiconductor Polishing • **JEWELRY:** Gem Stone and Crystal Polishing; Silver Polishing • **LIGHTING:** Phosphor Preparation • **CERAMICS:** Pure Oxide Ceramics • **METAL FABRICATION:** Finishing of Metal Parts; Knife Sharpening; Microtome Knife Sharpening; Razor Blade Sharpening • **METALLURGY:** Metallographic Polishing • **OPTICAL:** Glass Polishing

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

UNION CARBIDE

LINDE and UNION CARBIDE are registered trade-marks of Union Carbide Corporation

TRAPEZOIDAL-SPRING DEFLECTION continued



terial is where needed most: deepest cross-section is at root of the spring, where stresses are highest. And shallowest cross-section is where stresses are least.

Here's an example of the correction-factor method:

PROBLEM: What is the total deflection of the contact spring shown on p 83? (Assume $E = 14.5 \times 10^6$ and $\lambda_{max} = 55$ for material in this spring.)

SOLUTION: First find

Maximum permissible load $P_{max} = bh^2 \lambda_{max}/2L$
$= 0.6 \times 1^2 \times 55/2 \times 12.57$
$= 0.458$ kg

Moment of inertia $I = bh^3/12$
$= 0.6 \times 1^3/12 = 0.05$ mm^4

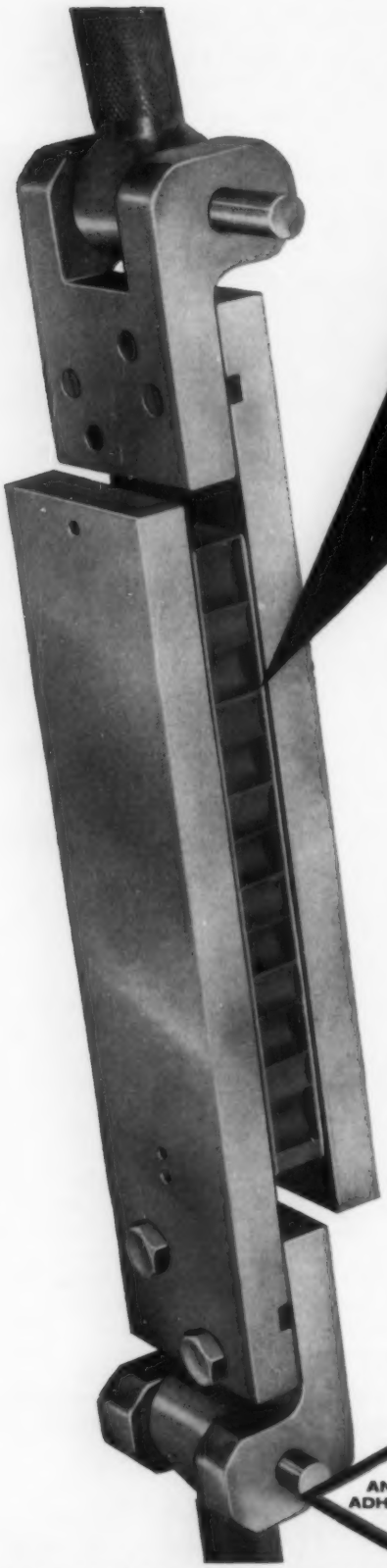
In calculation for deflection, insert correction factor. Enter correction-factor curve with thickness parameter

$$\beta = 1 - h_0/h$$
$$= 1 - 0.65/1$$
$$= 0.35$$

and find correction factor $K = 1.35$.

Deflection $f = KPL^3/3EI$
$= 1.35 \times 0.458\ (12.57)^3/3 \times 14.5 \times 10^6 \times 0.05$
$= 0.56$ mm

Gap increases twice this, or 1.12 mm.



ANGIER

CONTACT CEMENTS

SUPERB BONDING AT LOWER COST

FOR YOUR CONTACT LAMINATIONS

Makers of honey-comb or sandwich panels report that Angier Contact Cements deliver an extra measure of both savings and bonding performance.

Easier spraying means greater mileage—a substantial S-T-R-E-T-C-H to your adhesives dollar. Smoother, more uniform films provide better bonding—show excellent resistance to dead load, creep, destructive cycling. Angier-bonded curtain walls have been found to satisfactorily withstand the weather-temperature extremes of northern climate for five years.

Whether for hot or cold bonding, Angier has the *right* contact cement for any type of core and face normally in use. Variations of eight basic formulations provide working properties to meet your particular plant conditions and end uses . . . some even allowing open time up to 1½ hours before nip roll combining.

Angier is a recognized specialist in contact cements. Call on Angier "know-how" and technical service.

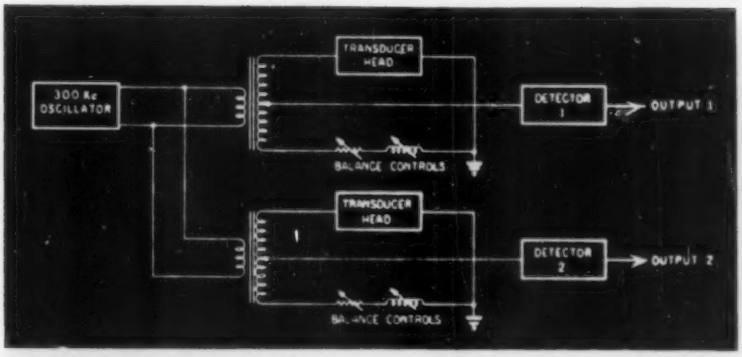
NEW BROCHURE—"Custom Formulated Adhesives for Industry" is now available without charge. For your copy, write on your company letterhead to Dept. P-12.

ANGIER ADHESIVES

Interchemical CORPORATION Finishes Division

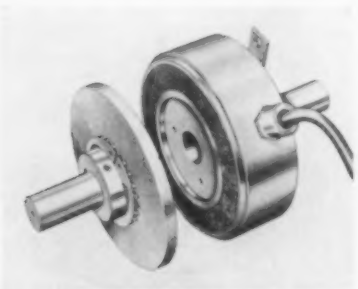
Headquarters Office: 224 McWhorter St., Newark 5, N.J. Factories: Chicago, Ill. • Cincinnati, Ohio • Elizabeth, N.J. • Los Angeles, Calif. • Newark, N.J. • Mexico City, Mex. Adhesives plants at: Cambridge, Mass. • Huntington, Ind. **IC and ANGIER are trademarks of Interchemical Corporation.*

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



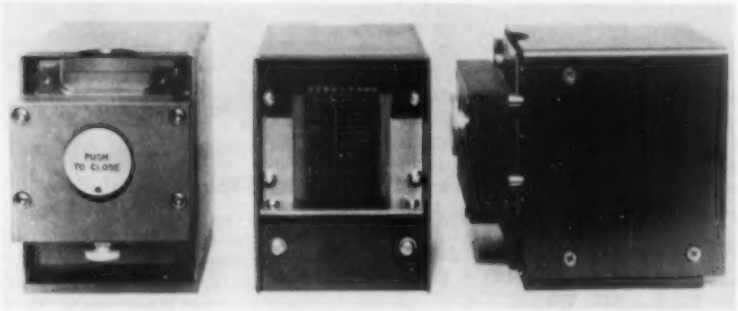
Noncontact sensing heads . . .
reduce wear on position-transducer designed for machine-tool automatic systems. Unit operates by magnetically sensing shaft rotation and converting to digital pulses as a measure of linear motion. Detects 0.0001-in. increments at up to 120-ipm position speeds, or 0.001-in. increments at speeds of 200 or more ipm. Inertia is stated at 0.3 oz-in.^{2} Priced at $295 without electronics. Delivery in 30 days. **Rheem Electronics, Div Rheem Mfg Co., 5200 W 104th St, Los Angeles.**

Circle 300 on Reader Service Card



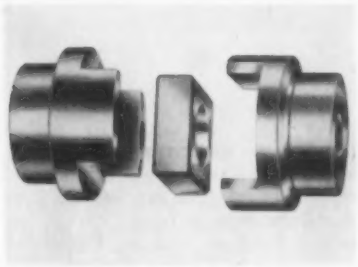
Stationary magnet clutch . . .
has ball bearing-mounted magnet for ease of assembly and alignment. Coils can be wound for voltages up to 115 v, dc and insulated with Classes A through H insulation. Torque, rated at 45 lb-ft, is transmitted through a splined armature to driven hub. Unit can be converted to magnetically set brake by securing rotor to magnet body. Available in split and through-shaft arrangements at $100 each. Delivery: 2 wk. **Stearns Electric Corp, 120 N Broadway, Milwaukee.**

Circle 303 on Reader Service Card



Punched-card switching system . . .
has 72 switches. Cards are punched according to selection of switches required for specific control sequence or required machine elements. Weighs 3 lb, 3 oz and measures 3⅞ x 5 x 4½ in. Available from stock at $285. **Taurus Corp, 8 Coryell St, Lambertville, NJ.**

Circle 301 on Reader Service Card



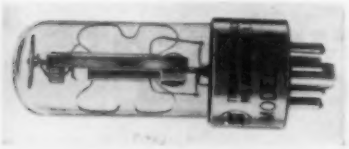
Self-lubricating flexible coupling . . .
has sintered-steel, oil-impregnated center member which absorbs and retains high-grade lubricating oil for long periods and dispenses it to bearing surfaces as needed. Jaw flanges are positioned at right angles to each other and engage opposite parallel surfaces of floating center member. Accomodates ±1% angular misalignment. Twenty-two sizes, available from stock, range in capacity from 0.05 to 985 hp at 100 rpm and in max speeds from 3600 to 500 rpm. **Zurn Industries Inc, Mechanical Power Transmission Div, Erie, Penna.**

Circle 304 on Reader Service Card

continued on page 88

Adjustable interval timer . . .
uses escapement mechanism driven by miniature permanent-magnet motor operating virtually at stall as time base. Accuracy is ±1% through full range of setting, which is 0.2 to 28 sec, in 0.2-sec increments. Any change in setting after starting causes timing cycle to abort. Originally designed for low-altitude bombing, units is 2¼ in. dia x 6 in. long and weighs 27 oz. Operates on 24 v, dc. **Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.**

Circle 302 on Reader Service Card



Hermetically sealed relays . . .

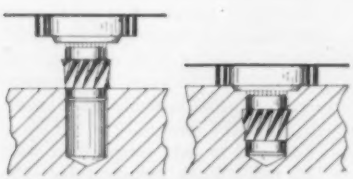
are said to last for at least 500,000 operations at rated load. Delay ranges are 5 sec to 3 min., with tolerances of ±15%. Ambient compensation is −85 to 257 F. Suitable for sequence operations, motor starting, holdover circuits, detecting prolonged surges and delaying magnetic relays. Standard switches, rated at 3 amp, 115 v, ac, are priced from approximately $3.50 to $4.50. Delivery in 2 to 3 wk. Six-amp models are available on special order. **Thermal Controls Inc, 41 River Rd, North Arlington, NJ.**

Circle 305 on Reader Service Card

Miniature indicator light . . .

has back-lighted ⅜ x ⅞-in. plastic head which accommodates two ½-in. or three smaller-size digits or letters. Uses midget flanged, 6-, 12- or 28-v bulb. Plastic faces are available in a variety of colors. Price ranges from $1.10 to $1.75. **Glar-Ban, Corp, 110 Glar-Ban Bldg, 3807 Harlem Rd, Buffalo 15.**

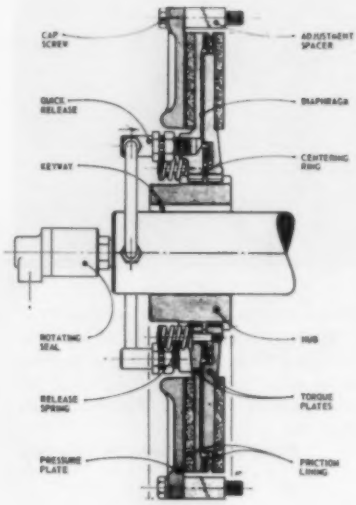
Circle 306 on Reader Service Card



Self-locking screw insert . . .

forms bond with material into which it is inserted by cold-flowing material into recessed grooves. Can be pressed into place with tool (which automatically peens material surface over chamfered edge at top of insert), permitting gang insertions. Insertion force ranges from 3 tons for aluminum inserts to 4½ tons for cold-rolled steel inserts. Also available in free-machining brass and stainless steel. Can be used in aluminum, steel, bronze, magnesium, iron, plastics and wood. **Bergen Laboratories Inc, Torq-Loc Div, 60 Spruce St, Paterson 1, NJ.**

Circle 307 on Reader Service Card



Compact air clutch . . .

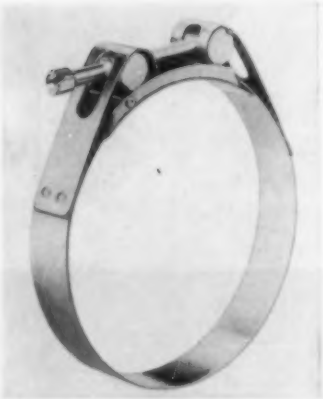
delivers 32,500 in.-lb torque at 80 psi in 16-in. model; 52,200 in.-lb in 18-in. model. Has fiberglass-reinforced, silicone-rubber diaphragm suitable for 500 to 600-F service. Heat-generating pressure plates are placed to outside for cooler running. Self-centering ring is said to eliminate internal drag. At 100 rpm, 16-in. model has 50-hp and 18-in. model, 82-hp capacities. Speeds range from max 2200 rpm in 16-in. model to 2000 rpm in 18-in. model. From stock at $419.50 and $492. **Mid-States Industrial Clutch Co Inc, 6045 N Broadway, PO Box 848, Wichita, Kan.**

Circle 308 on Reader Service Card

Rotating-cam limit switch . . .

has plug-in, snap switch receptacles that are permanently wired to screw-type terminals. Allows circuits to be disconnected or removed. By loosening screw and rotating cams relative to each other, a continuous range of open and closed circuit can be obtained from 360 to 8 deg. SPDT switch contacts have 15-amp rating at 115 v, ac; 10 amp at 220 v, ac; 5 amp at 440 v, ac; 0.5 amp at 110 v, dc; and 0.25 amp at 220 v, dc. Available with two to 24 circuits. **Gemco Electric Co, 25685 W Eighth Mile Rd, Detroit 40.**

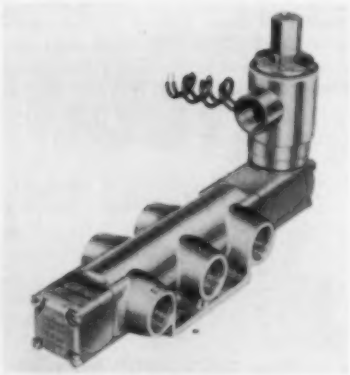
Circle 309 on Reader Service Card



Heavy-duty band clamps . . .

for ducting applications on sleeves, air filters and hose, are offered in 28 sizes with diameters from 2⅝ to 7¾ in. Strap and bridge are made of stainless steel. Nut, lug and screw are in cadmium-plated cold-rolled steel. **Wittek Mfg Co, 4305-43 W 24th Pl, Chicago 23.**

Circle 310 on Reader Service Card



Balanced-spool solenoid valve . . .

needs only small force to actuate it, safeguarding it from effects of operating pressures. Enclosed in forged-bronze body, valve has no external moving parts. Available in explosionproof, dustproof, waterproof and fungusproof constructions with sizes from ⅛ to ½-in. NPT in 2-, 3-, 4- and 5-way types. Operates on pressures from partial vacuum to 500 psig. Standard coils are rated at 110 v/60 c. **Versa Products Co Inc, 150 Coolidge Ave, Englewood, NJ.**

Circle 311 on Reader Service Card

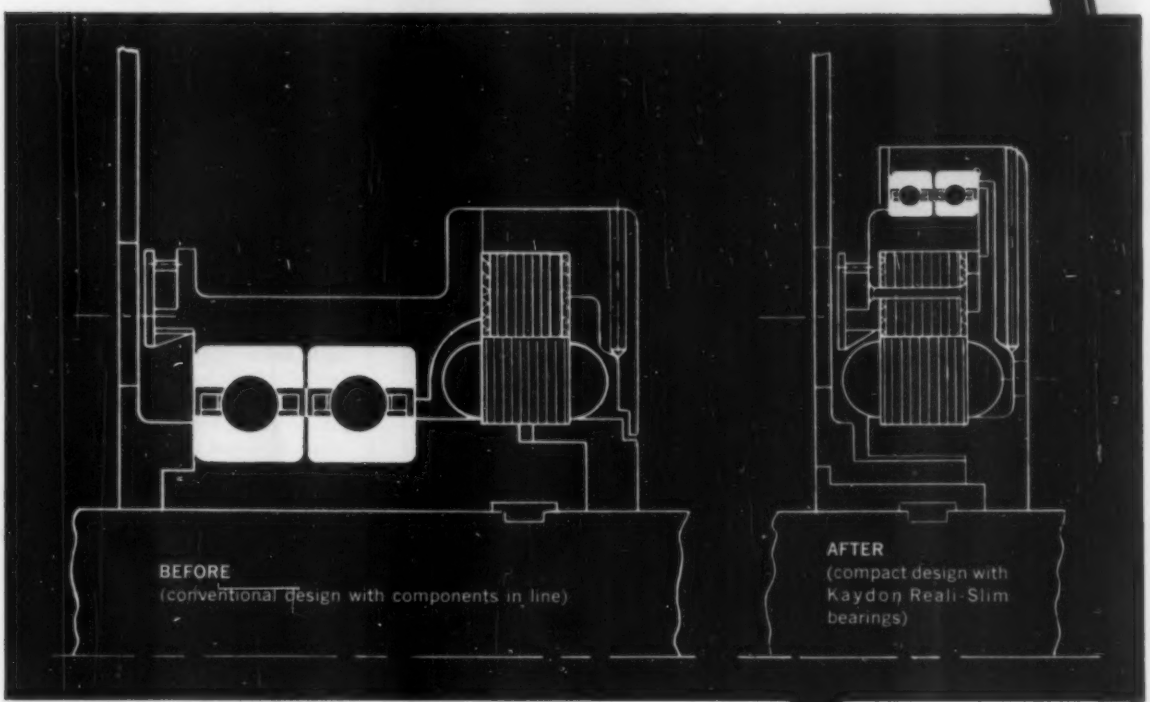
Disposable filter cartridge . . .

consists of spirally wound cellulose yarn and cotton fiber filtering medium constructed around perforated, heavy-gage metal core. Traps progressively finer contaminant particles from OD to core. Car-

continued on page 90

Don't let in-line design get in the way of a compact product...

"NEST" COMPONENTS INSIDE THE BEARING BORE



Motor assembly redesign shown above is typical of the way Kaydon Reali-Slim bearings save space, reduce weight, cut costs!

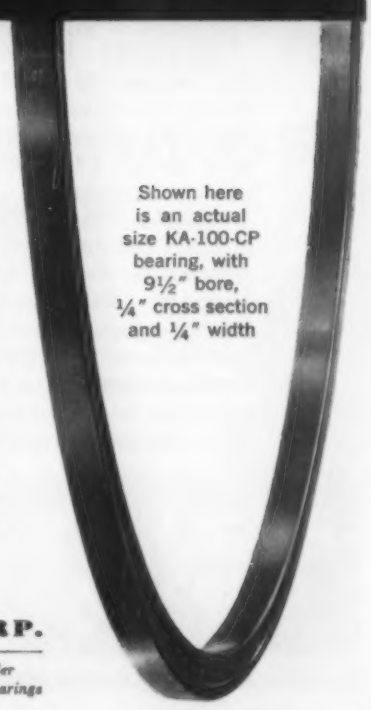
Kaydon thin-section Reali-Slim bearings provide valuable component space inside the bearing bore. And use of a hollow shaft permits utilizing this space for control rods, linkages, collets, counter-rotating shafts, clutches and brakes, to name a few possibilities.

With Reali-Slim bearings, you save weight and space in both bearing and housing, reducing costs for materials, shipping, storage and handling.

And large-bore Reali-Slim bearings give closer support to the outer edge of rotating parts, instead of the center only, which gives more rigidity and accuracy for moment loads.

Stocked in 90 sizes! These Kaydon Reali-Slim Type CP bearings have Conrad deep-groove, ball-radial construction and new bronze, one-piece snap-over separator in 4" to 12" bore—¼" to 1" width and cross section. Kaydon's volume production cuts prices up to 76%, depending on size.

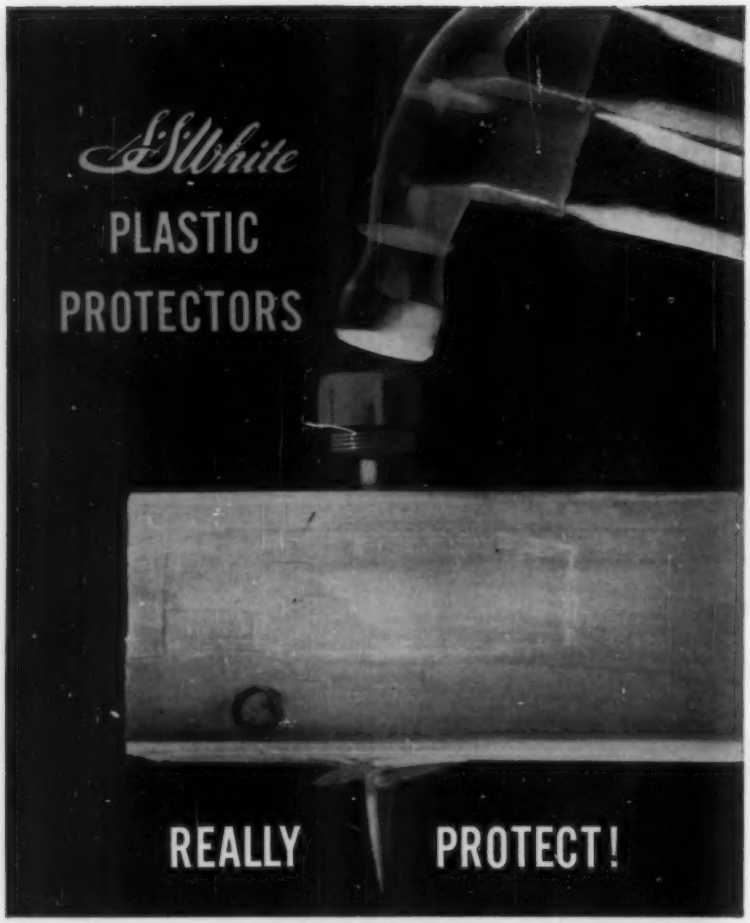
Contact Kaydon now. Have the Kaydon sales engineer or distributor salesman in your area discuss Reali-Slim bearing applications for *your* products. Or write for free, fact-full "CP" bearing bulletin—with prices.



Shown here is an actual size KA-100-CP bearing, with 9½" bore, ¼" cross section and ¼" width

THE KAYDON ENGINEERING CORP.
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings



Driven through a 4x4...threads unhurt!

Yes, we actually did it! We fitted an S. S. White **Quality Line** plastic protector to this test piece (a spike with one end threaded). Then we drove the spike through a four-by-four *by hammering on the rigid acetate protector.*

We found that despite the terrific pounding, both the protector and *the delicate threads it was assigned to protect came through undamaged!*

Here is the ultimate in security for your products during shipping, storage, processing... quality protection your customers will appreciate!

Check our **Economy Line** too. Elastic vinyl plastic protectors that have a stay-put fit and a non-slip grip for quick, easy removal. Absolutely non-shredding.

WRITE FOR BULLETIN

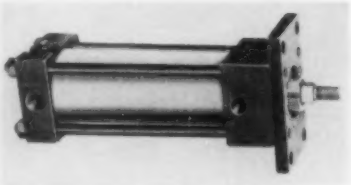
0142 *P-5708 and Free Samples*

S. S. White **PLASTICS DIVISION**

Dept. 14P, 10 East 40th Street, New York 16, N. Y.

tridge ends are wound square with core axis, enabling many cartridges to be assembled end-to-end in tiered arrangements. Measures 9⅞ in. long with 1-in. core and 2¼-in. OD. Filter density is from 10 to 75 microns. **Cumo Engineering Corp, 80 S Vine St, Meriden, Conn.**

Circle 312 on Reader Service Card



Interchangeable air cylinders

are also suitable for hydraulic operations. Cap-screw-held bearing plates reportedly give true alignment to bearings, yet permit removal of bearing cartridge assemblies as single units. Tapered cushions give uniform deceleration on hydraulic cylinders. Fatigueproof steel piston rods with hard chrome plating and wrench flats and high-tensile alloy-steel tierods are used. Available in 1½ to 14-in. bore diameters. **W E Hennells Co Inc, 434 Sumpter Rd, Belleville, Mich.**

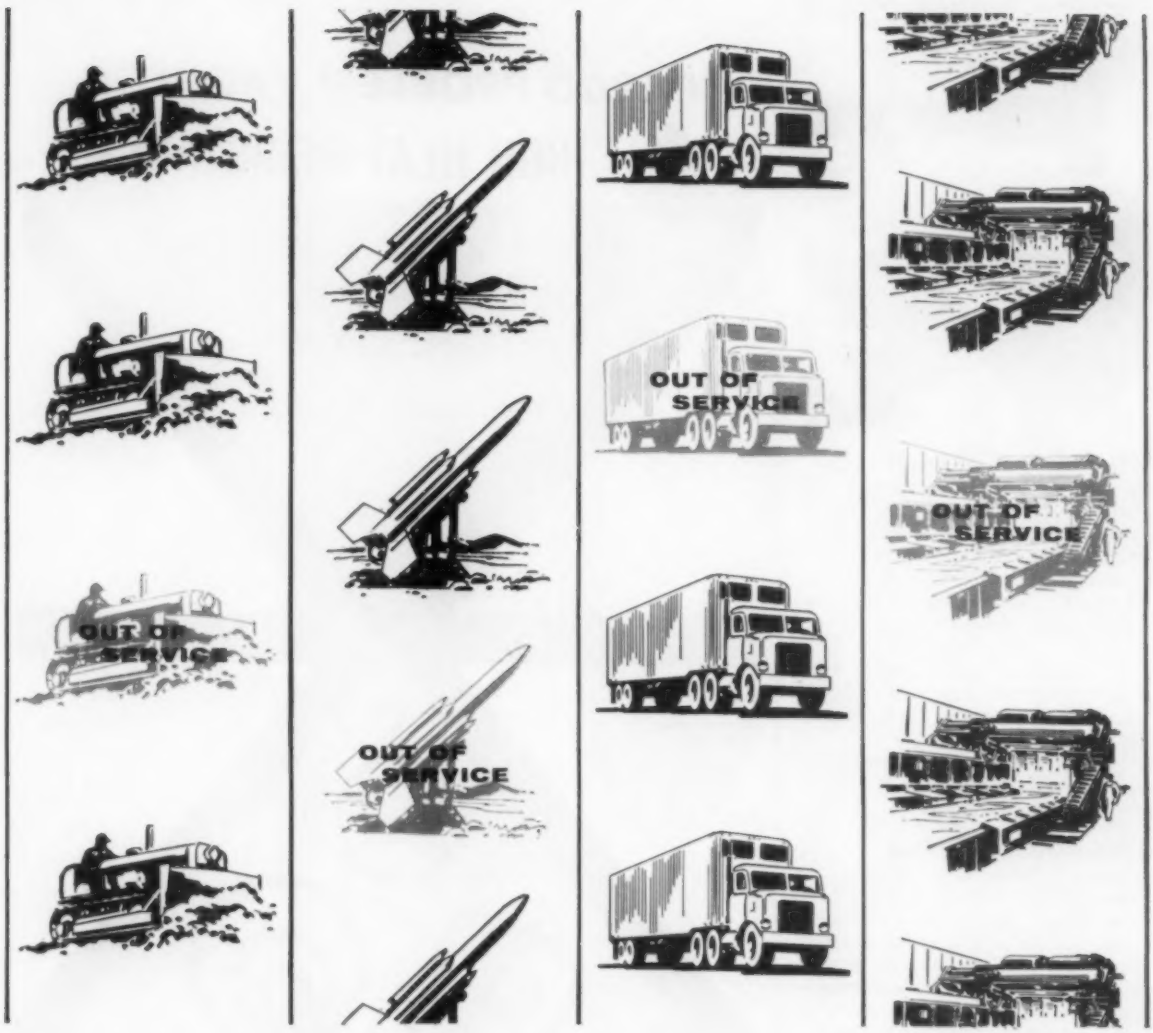
Circle 313 on Reader Service Card

Metal-cased limit switches . . .

handle up to 2 hp at 250 v, ac or 20 amp at 125 v, ac during 1P2T operation. Feature right- or left-hand mounting and O-ring sealed side plate and neoprene boot-sealed operating plunger. Can be connected outside metal cases. Operation is by direct-overtravel plunger, roller-overtravel plunger, adjustable roller-arm or adjustable hand actuator. **Unimax Switch Div, W L Maxson Corp, Ives Rd, Wallingford, Conn.**

Circle 314 on Reader Service Card

continued on page 92



Dependable ROLLWAY BEARINGS

help keep your down-time low

When a bearing "goes", your machine stops.

That's why it pays to call in Rollway. Especially when reliability is a must.

At Rollway, you can choose from a wide selection of sizes and types with maximum capacities . . . for normal, low or high temperature operation. All meeting or exceeding RBEC requisites in Classes 1 to 5.

You'll find that Rollway meets your needs exactly – in commercial grade, precision, or ultra-precision bearings. To get the bearing you want in a hurry, or to start R and D on the bearing you've been dreaming about, just call or write Rollway Bearing Company, Inc., Syracuse 1, New York.

Where So Much Depends on So Little . . . You can depend on

ROLLWAY BEARINGS

Radial and Thrust Cylindrical Roller Bearings

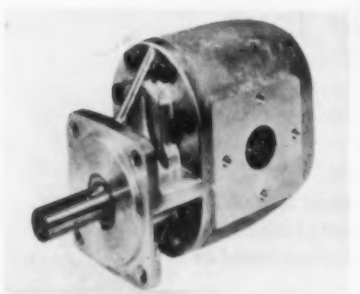
ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • LosAngeles • SanFrancisco

Self-sealing disconnect . . . has push-pull locking arrangement that eliminates threaded joints. Lock can be operated with one hand or with remote-control devices. Said not to leak or allow in air during connect-disconnect. After disconnect, no seals are exposed and coupling valve maintains full 4000 psi pressure. Temperature ratings range from —65 to 400 F, depending upon type of seal. Available for ¼- to 1¼-in. tube sizes. **Symetric Inc, 3100 Airport Ave, Santa Monica, Calif.**

Circle 315 on Reader Service Card

Silicone-rubber cement . . . adheres at —100 to 500-F. Bonds silicone rubber to itself or to glass, Dacron and nylon fabrics. Can be used with metal primer to bond silicone rubber to metal, plastics, and ceramics. Thermal cures to form bond with 8 to 15-psi peel strength. Available from stock in 8-, 16- and 32-oz containers. **Connecticut Hard Rubber Co, 407 East St, New Haven 9, Conn.**

Circle 316 on Reader Service Card

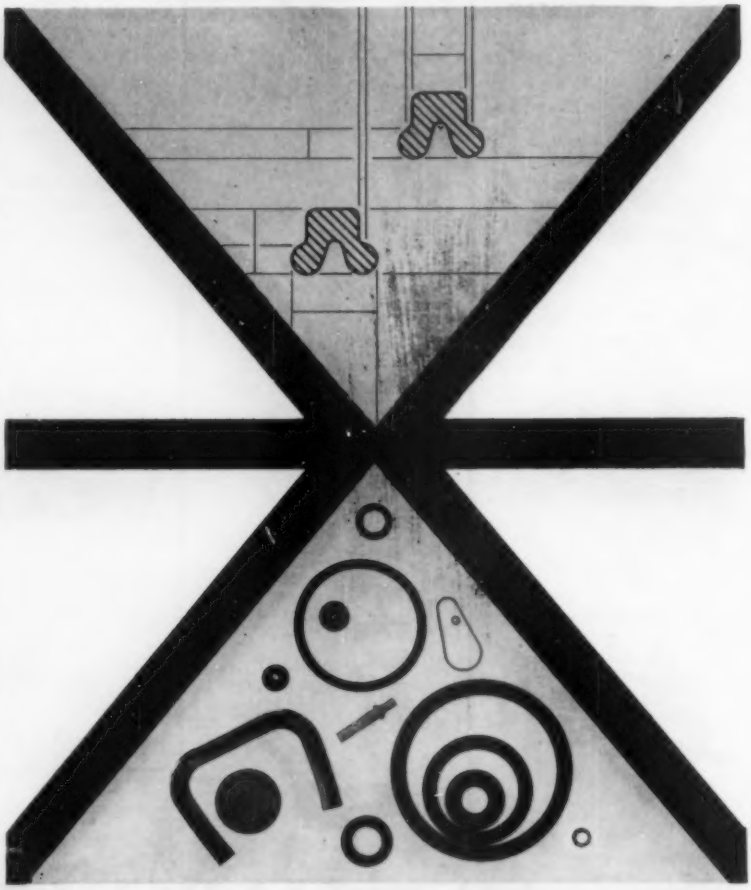


Pressure-balanced gearpumps operate at mobile equipment engine speeds of 2800 rpm. Reach flow rate of 60 gpm and operating temperature of 250 F with min oil viscosity of 55 SSU. Accept continuous pressures to 2250 psi. Discharge pressure maintains optimum counterbal-

continued on page 96

PARCO PROBLEM PROBERS

???...HIGH HEAT RESISTANCE



!!! If high heat resistance is a requirement of the molded rubber components or "O" Rings in your product design, Viton molded products, by Parco, are the answer. Viton will withstand temperatures up to 600° F. It has excellent wearability and is chemically resistant to oil. It is also resistant to chlorinated and aromatic solvents. ◯ These favorable properties, coupled with Parco's scientifically controlled production facilities and precise quality control techniques assure the ultimate in Viton molded rubber components for your high temperature applications. ◯ Parco is qualified to produce Viton products in conformance with MIL-R-25897C. For immediate results, consult with Parco engineers regarding your molded rubber applications where high temperature resistance is necessary.

Send for your latest Parco Slide Rule

Parco

Plastic and Rubber Products Company
2100 Hyde Park Boulevard
Los Angeles 47, California

Plastic and Rubber Products Company
2100 Hyde Park Blvd. • Los Angeles 47, Calif.
Please send the Parco O-Ring Data Chart to:

NAME_____

COMPANY_____

BUSINESS ADDRESS_____

CITY_____

ZONE____ STATE_____

CIRCLE 92 ON READER SERVICE CARD

PARCO TEFLON

POLYETHYLENE
NYLON • KEL-F†
DELRIN**

ENVIRONMENTALLY CONTROLLED PARCO TEFLON* SHAPES YOUR TOMORROW'S PRODUCTIVITY

Designed for tomorrow... but producing today, Parco's unique environmentally controlled facilities assure the purest quality Teflon available. Engineered with advanced temperature and pressurization equipment, the Parco Fluorocarbon plant maintains a surgically clean, temperature-humidity controlled environment *essential* for reliable Teflon performance. Thus undesirable expansion and contraction as well as dust inflicted product weakness characteristics are entirely eliminated ■ Parco's Fluorocarbon Engineering Department will provide the personal attention your specific Teflon or Fluorocarbon problem requires ■ Standard AN & MS parts are stocked and immediately available: **O-Rings • V-Rings • Scraper Rings • Grommets Static Face Seals • Back Up & Spiral Back Up Rings • Send for free Parco Fluorocarbon Data Chart and Back Up Ring brochures.**

PLASTIC AND RUBBER PRODUCTS COMPANY

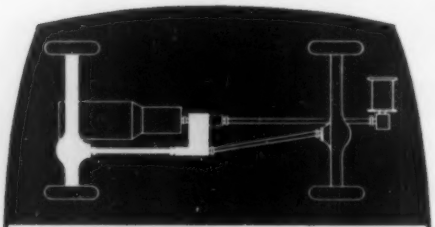
2100 Hyde Park Boulevard, Los Angeles 47, Calif. / *FLUOROCARBON DIVISION*

*Teflon-DuPont Trademark for T.F.E. fluorocarbon resin **DuPont Registered Trademark for Acetal Resin †Kel-F—M.M.&M. Trademark

CIRCLE 93 ON READER SERVICE CARD 93

When you need "pull" power as well as "push"...

THE ANSWER IS TIMKEN-DETROIT® FRONT DRIVING AXLES!

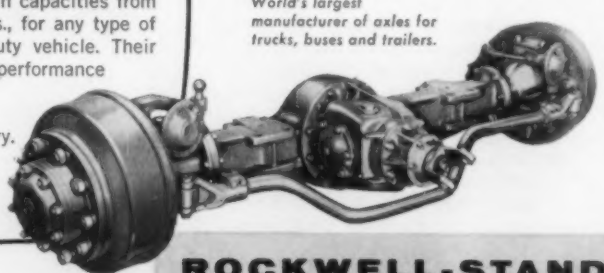


Rockwell-Standard produces front driving axles ranging in capacities from 4,800 lbs. to 20,000 lbs., for any type of medium and heavy-duty vehicle. Their record of outstanding performance on large off-highway fleets is unequalled throughout the industry.

There are many times when you need the extra power of front driving axles in rugged off-highway operations. And only the complete line of Timken-Detroit front driving axles and transfer cases best meets every requirement for these multi-wheel drive assemblies.

For more than 50 years, Rockwell-Standard has supplied components for multi-wheel drives. Rockwell's design, engineering and manufacturing experience—plus advanced research and testing facilities—assures highest quality. Use vehicles with multi-wheel drive for peak off-highway performance . . . *and specify Timken-Detroit!*

World's largest manufacturer of axles for trucks, buses and trailers.



Another Product of...

ROCKWELL-STANDARD CORPORATION

Transmission and Axle Division, Detroit 32, Michigan

NORGREN SALES AND SERVICE REPRESENTATIVES

ATLANTA 11, GA.
Air & Hydraulics Eng., Inc.
Diamond 4-3433

BALTIMORE 18, MD.
N. B. Cochrane Co.
HOpkins 7-4884

BIRMINGHAM 5, ALA.
Air & Hydraulics Eng., Inc.
ALpine 2-6101

BUFFALO, N. Y.
Goll-Hanford Corp.
SPring 7200

CEDAR RAPIDS, IOWA
Walter Norris Eng. Co.
EMpire 3-0438

CHARLOTTE 7, N. C.
L. W. Kinnear & Co., Inc.
FRanklin 6-7553

CHICAGO 6, ILL.
Walter Norris Eng. Co.
STate 2-2804

CLEVELAND 7, OHIO
F & W Ursem Co.
LAkewood 1-9136

DALLAS 35, TEXAS
Leo. J. Schindler Co., Inc.
LAkeside 8-0517

DAYTON, OHIO
K. C. Mosier Co.
BA 4-9805

DENVER, COLO.
E. C. Wild Co., Inc.
SHerman 4-1253

DES MOINES, IOWA
Walter Norris Eng. Co.
ATlantic 2-8782

DETROIT 28, MICH.
William H. Nash Co., Inc.
BRoadway 3-7493

EVANSVILLE, IND.
Neff Engineering Co.
GReenleaf 7-4141

FLINT 2, MICH.
William H. Nash Co., Inc.
CEdar 5-0444

FT. LAUDERDALE, FLA.
Air & Hydraulics Eng., Inc.
LUdlow 3-5657

FORT WAYNE, IND.
Neff Engineering Co.
EAstbrook 7391 & 2

GRAND RAPIDS, MICH.
William H. Nash Co., Inc.
GL 2-0929

HARTFORD, CONN.
Pearse-Pearson Co., Inc.
Broomfield, Conn.
CHapel 2-7777

HONOLULU 13, HAWAII
Chapson Bros., Ltd.
57-306

HOUSTON 11, TEXAS
Leo J. Schindler Co., Inc.
WAlnut 3-2525

HUNTINGTON, W. VA.
K. C. Mosier Co.
JAckson 5-4831

INDIANAPOLIS 2, IND.
Neff Engineering Co.
WAlnut 5-5311

KANSAS CITY 15, KAN.
Air Equip. Co.
DRexel 1-3709

LOS ANGELES, CALIF.
The Teglen Eng. Co., Inc.
So. Pasadena, Calif.
MUrray 2-2856

LOUISVILLE, KY.
Charles Weber Co.
MElrose 7-2574

MILWAUKEE 8, WIS.
C. L. Thompson Co.
HIlltop 4-4817

MINNEAPOLIS 4, MINN.
H. U. Rogness
FEderal 3-5595

MOLINE, ILL.
Walter Norris Eng., Co.
764-1196

NEEDHAM, MASS.
Pearse-Pearson Co., Inc.
hillcrest 4-1090

NEWARK, N. J.
K. E. Knotts Co.
Westfield, N. J.
ADams 2-8700

NEW YORK, N.Y.
K. E. Knotts Co.
BArclay 7-7455

OKLAHOMA CITY, OKLA.
Nix Supply Co.
ORange 7-6623

PHILADELPHIA, PA.
J. A. Moody Co.
Wayne, Pa.
MUrray 8-3750

PHOENIX, ARIZ.
Air-Draulics Co.
ALpine 8-6441

PITTSBURGH 26, PA.
Leonard R. Nourie, Inc.
LOcust 1-1628

PORTLAND 9, ORE.
Power Transmission Products
CA 7-1272

PROVIDENCE, R. I.
Pearse-Pearson Co., Inc.
GAspee 1-2557

RICHMOND 29, VA.
C. Arthur Weaver Co., Inc.
ELgin 9-5771

ROCHESTER 18, N. Y.
Goll-Hanford Corp.
GReenfield 3-8323

ROCKFORD, ILL.
Walter Norris Eng. Co.
WOodland 3-2811

SAN FRANCISCO, CALIF.
Airdraulic Ind. Products Co.
Burlingame, Calif.
Diamond 2-7297

SEATTLE 9, WASH.
George W. Warden Co.
ATwater 3-0622

SHREVEPORT, LA.
Harris Frederic & Co., Inc.
5-7455 & 5-7456

ST. LOUIS 18, MO.
Sturgis Equip. Co.
OLive 2-5380

STRATFORD, CONN.
Pearse-Pearson Co., Inc.
DRexel 8-2992

SYRACUSE 3, N. Y.
Ralph W. Earl Co.
GRanite 5-5145

TULSA, OKLA.
Nix Supply Co.
Diamond 3-8916

VANCOUVER, B. C.
Galbraith & Sulley, Ltd.
CHerry 5121

LACHINE-MONTREAL, QUE.
Cowper Co., Ltd.
MElrose 7-6746

TORONTO, ONT.
John Spotton Co., Ltd.
CLifford 9-8276

Norgren Diaphragm-Type Relief Valves and Flow-Control Valves

Diaphragm-Type Relief Valve

Type 62AX— for use with air, water, oil and similar fluids. ⅛", ¼", ⅜", ½", ¾", 1" pipe sizes. For relief pressures up to 250 psig (¼", ⅜", ½") and up to 125 psig (¾", 1").

Compact Diaphragm-Type Relief Valve

Type 40AB— for use with air, water, oil and similar fluids. ⅛", ¼" pipe sizes. Relief pressure adjustable up to 100 psig.

Pop Safety Valves

Type 1000— for air. ⅛", ¼", ⅜", ½" pipe sizes. Relief pressure ranges: 25 to 200 psig.

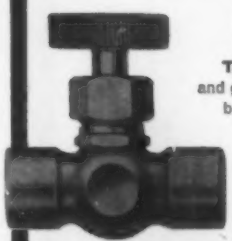
Flow Control Valves

Types 1100 and 1200— for air, oil, hot and cold water, steam, non-corrosive gases and liquids. Two-way and single-way valves. ¼", ⅜", ½" pipe sizes. Max. pressure: 250 psig on air and hydraulic systems, 125 psig on saturated steam and hot water systems.

Low Flow Relief Valves

Type 61A— for air, water and non-corrosive gases. ⅛", ¼" pipe sizes. For relief pressures: 25 to 300 psig.

Needle Valves



Type N— for air, liquids and gases that do not affect brass. ⅛", ¼" pipe sizes. Maximum pressure: 250 psig.

For complete information on these products or the complete Norgren line of compressed air filters, pressure regulators and lubricators, call your nearby Norgren representative, listed at left—or write for descriptive literature.

C. A. NORGREN CO. FOUNDED IN 1926

3428 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

CIRCLE 95 ON READER SERVICE CARD 95

anced thrust of journal bearings toward gear faces to control leakage and wear. Envelopes, flanges, portings, shafts all based on SAE standards. **Berry Hydraulics, Corinth, Miss.**

Circle 317 on Reader Service Card

Miniature air-line assembly . . .

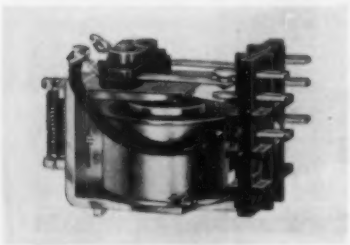
consists of filter, regulator and lubricator and is available from stock in ⅛- and ¼-in. sizes, with max 150 psi operating pressure. Filter has 20-micron porous-bronze element, while lubricator's bypass design reportedly provides lubrication at 0.2 to 15 cfm flow rates without excessive pressure drop. **Watts Regulator Co, Industrial Div, Lawrence, Mass.**

Circle 318 on Reader Service Card

Lightweight pressure-transducer . . .

requires only 3 ma at 28 v, dc for 0- to 5-v, dc output. Five-oz unit operates at up to 5000 psig pressure. Has 1 k-ohm output impedance and mutually isolated input, output and ground circuits. Uses no amplifiers. **Daystrom-Wiancko Engineering Co, 255 N Halstead St, Pasadena, Calif.**

Circle 319 on Reader Service Card



General-purpose relay . . .

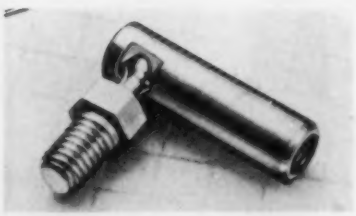
features riveted crossbar and linen-base phenolic insulator between crossbar and armature. Wires from crossbar to front panel are 20-gage rope-lay types which reportedly are less likely to break. Five- and 10-amp models are available. **Electronics Div, Elgin National Watch Co, 2435 N Naomi St, Burbank, Calif.**

Circle 320 on Reader Service Card

High-temperature transducer

performs at —100 to 600 F during shocks exceeding 100 g for 11 millisec. Precalibrated to measure absolute or gage full-scale pressures of 200, 500, 1000 or 2000 psi. Repeatability is 0.1%, and combined max nonlinearity and hysteresis are 0.5% of full scale. Requires 10 v, ac or dc. Measures approximately 2⅝ in. long x 1⅛ in. dia and weighs 3.5 oz. Either flush-mounting diaphragm or threaded pressure fitting for ¼-in. flared tubing is available. **Electro-Mechanical Research Inc, Sarasota, Fla.**

Circle 321 on Reader Service Card



Miniature ball joint . . .

provides free movement to ball, with no binding at neck. Shell measures ⅝ in. long x ¼ in. dia. Ball screw is ⅜ in. long to ball center, with ¼-in. hex-wrenching flats and 10-32 thread. Female threads in shell's tapped hole run from sizes 4 to 10. **J J Tourek Mfg Co, 1901 S Kilbourn Ave, Chicago 23.**

Circle 322 on Reader Service Card

Flexible driveshafts . . .

teamed with neoprene-covered casings and standard couplings, reduce production time and costs by eliminating belts, gears and universals. Suitable for prototype or medium-volume requirements. Can be used in either rotational direction. From stock in 0.150 to 0.500-in. sizes, standard lengths. **S S White Industrial Div, 10 E 40th St, New York 16.**

Circle 323 on Reader Service Card

Miniature circuit breaker . . .

interrupts up to 5000% of its 50-amp capacity. Tests indicate unit will last for more than 10,000 cycles. Said to be sand-, dust- and corrosion-resistant and to handle shocks in excess of 25g. Size permits more than usual circuit breakers in a given area. **Wood Electric Corp, 244 Broad St, Lynn, Mass.**

Circle 324 on Reader Service Card

Fan and blower motors . . .

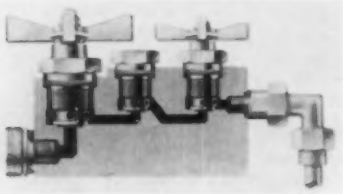
available in size 4500 frames, feature single-, two- or three-phase inputs, 26 to 230 v, ac and 25 to 400 cps frequencies. Provide 1½-hp outputs as induction motors; up to 300 in.-oz stall torque as torque motors; and from 1/200 to ½ hp as hysteresis synchronous motors (able to be wound for single-, dual-, three- and four-speed operation). Ambient temperature range is from —67 to 159.8 F. Units operating up to 302 F also are available. **IMC Magnetics Corp, Marketing Div, 6058 Walker Ave, Maywood, Calif.**

Circle 325 on Reader Service Card

Single-end magnetic clutch . . .

is direct-acting, with an output torque of 40 oz-in. at 24 to 28 v, dc. At same voltage, breakaway torque is 0.4 oz-in. when coil is energized and 0.05 oz-in. when coil is deenergized; power consumption is 3 w; and max recommended speed, 5000 rpm. **Sterling Precision Corp, 5 Sintsink Dr, Port Washington, NY.**

Circle 326 on Reader Service Card



O-seal cartridge inserts . . .

for high-pressure manifolds, has own flat seat which is sealed with an O-ring. When hand-operated valve is closed, nylon disc presses into Monel seal to bring about bubble-tight shutoff regardless of pressure at temperatures from —20 to 275 F. O-ring seals around stem and bonnet use line pressure to effect tight seal. Available in ¼ to 2-in. sizes. **Combination Pump Valve Co, Dept 125, 851 Preston St, Philadelphia 4.**

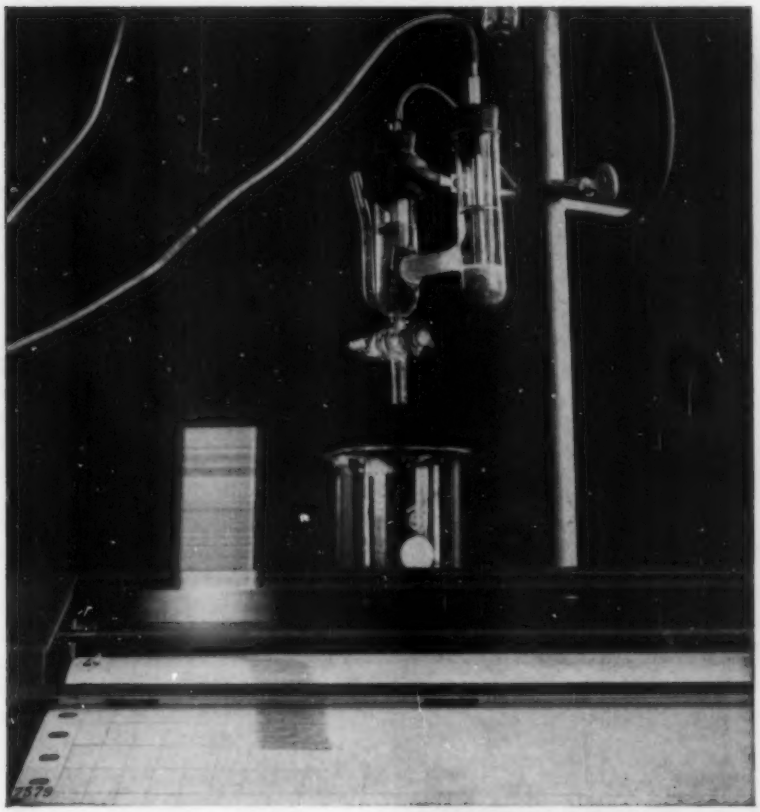
Circle 327 on Reader Service Card

Control-knob lock . . .

is made splash- and dust-proof for exterior use with potentiometers and other variable controls. Rubber insert molded over threaded metal bushing reportedly prevents water leakage around control shafts.

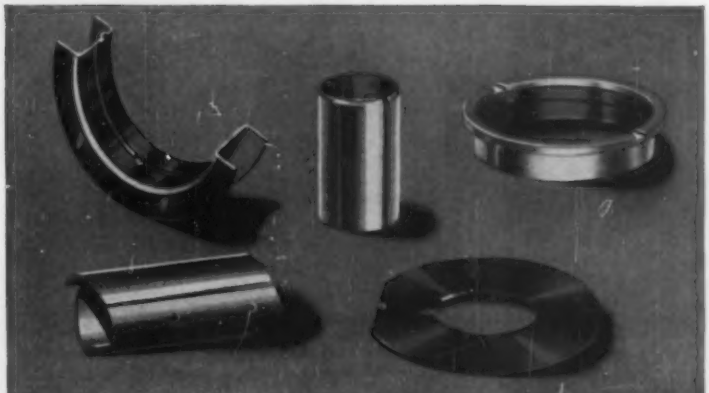
continued on page 100

ANALYTIC "BLOODHOUND" SNIFFS OUT SECRETS OF BEARING CORROSION



WE USE THIS HYPERSENSITIVE DEVICE TO TRACK DOWN ENGINE BEARING CORROSION TO ITS SOURCE. This instrument needs only a minute fragment of metal for accurate analysis. Consequently, engine bearing corrosion can be traced from its beginning through complete destruction of the bearing surface. Because test variables are minimized, Federal-Mogul engineers can accurately relate degree of corrosion to specific engine operating conditions. This analytical tool is in continual use in our laboratory, assisting research on many different projects. Prevention of corrosion and development of new bearing alloys are high on the list!

SUCCESSFUL BEARING PERFORMANCE depends on selecting the proper alloy for the operating conditions to be met. Federal-Mogul engineers have had years of experience with bearings and applications of all kinds . . . and this wealth of knowledge is available to bearings users. This is one reason why F-M sleeve bearings, precision thrust washers, formed bushings, and low-cost spacers are chosen for use in virtually everything from baby buggies to heavy industrial cranes.



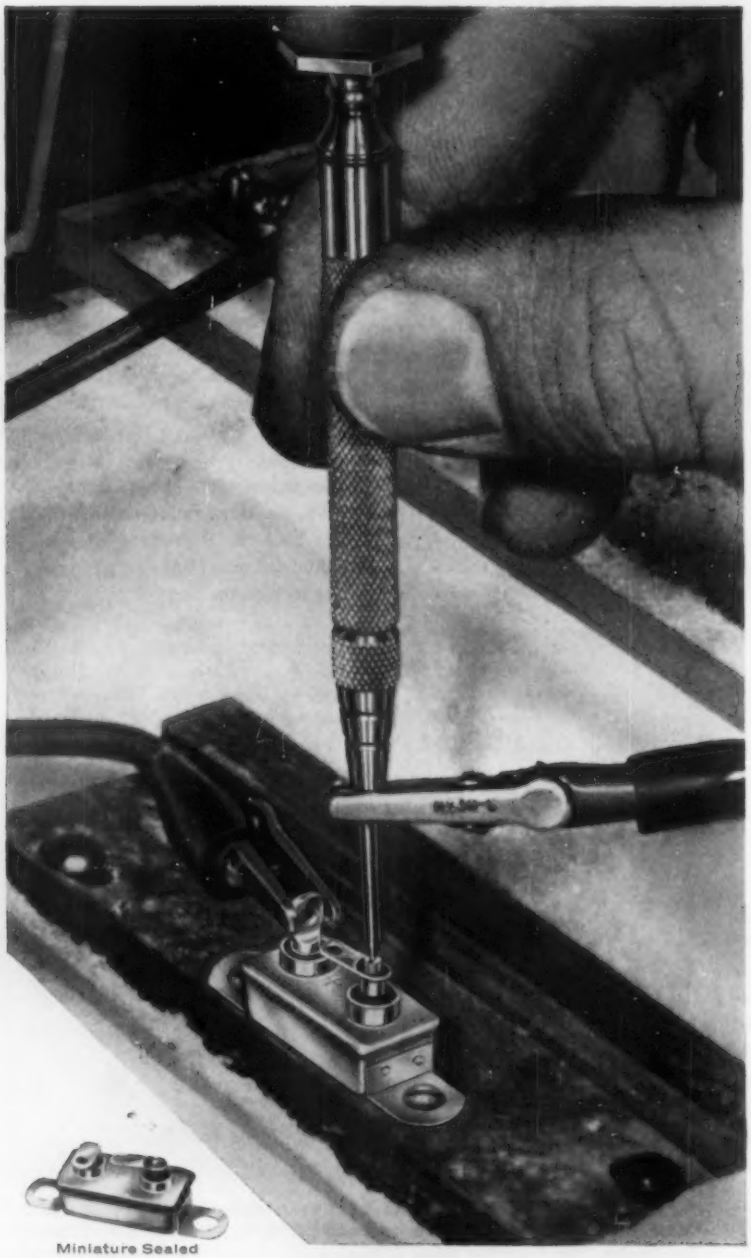
There's much valuable data in our Design Guides on sleeve bearings, thrust washers and bushings; and in our brochure on spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings · bushings · spacers · thrust washers

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

Tested To "Take It" on Missiles or Machines . . .



Miniature Sealed
THERMOSWITCH Unit
(actual size)

The Fenwal Miniature Sealed THERMOSWITCH® Unit

Here's the tiny temperature controller that's successfully handling some of today's toughest temperature control problems . . . in missiles and rockets as well as on production machines. Photo shows one of many quality control tests to insure product performance. *It's built to take a beating!*

Hermetically sealed, its rugged design permits normal control action even under the most severe conditions of shock and vibration. Stainless steel case is the heat-sensitive element . . . responds with instantaneous, positive action to heat changes of a fraction of a degree. Unit controls to extremely close limits. *Weighs less than ½ oz.!*

Easily set for *control* of temperatures from −20 to +200°F. When used as *high limit* switch, range is −20 to +275°F. Can withstand continuous exposure from −65 to +325°F. The Fenwal Miniature Sealed THERMOSWITCH Unit is widely used for crystal ovens, tuning forks, gyro assemblies, missile blankets, and missile batteries. Current rating: 2.5 amps, 115 VAC, 2.0 amps, 28 VDC. Find out how this advanced controller can protect the reliability of your product. Write Fenwal Incorporated, 35 Pleasant Street, Ashland, Mass.

Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 "V" Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

CIRCLE 99 ON READER SERVICE CARD 99

- Large Manufactured Head
- Oversize Blind Head
- Plugged or Hollow
- No Stem Trimming
- Minimum Blind-Side Clearance
- Excellent Head Seating
- Wide Grip Range
- Full Range of Diameters
- Positive Hole Fill
- Easy Installation

For fast, secure, more economical fastening, the new Cherry Commercial Rivet is a blind fastener ideal for production manufacturing and repair. Installed by one man from one side of the work, the Cherry Commercial Rivet reduces cost of assembly, repair and maintenance in both blind and open applications.

Minimum blind side clearance, adaptability to variations in material thickness, and positive hole fill even in oversize or out-of-round holes offer advantages not available in other production fasteners.

Cherry Commercial Rivets are available in both hollow (non-structural) and plugged (structural) types. The plugged rivets have strength values comparable to solid rivets, and stems fracture to eliminate all trimming operations and provide further production economy.

Grip lengths from 1/32" to 1" inclusive, and diameters of 1/8", 5/32", 3/16" and 1/4" are provided in either universal or countersunk head. Special rivets are manufactured to order.

For full technical information on the new Cherry Commercial Rivet, write Cherry Rivet Division, Townsend Company, Box 2157-D, Santa Ana, California.

Aluminum Mild Steel Monel

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

ESTABLISHED 1816 • BEAVER FALLS, PA

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

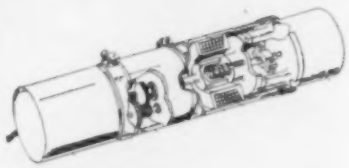
Unit locks control with 1/8 turn of its fluted skirt without disturbing critical settings. Prices range from $1.65 to $1.85. Delivery in 30 days. **Raytheon Co, Industrial Components Div, 55 Chapel St, Newton 58, Mass.**

Circle 328 on Reader Service Card

Radial airgap motors . . .

with flange-mounted construction, include ratings from 1/2 to 25 hp in speeds from 900 to 3600 rpm. Four different flange diameters come in 1, 1½ and 2 hp. A 13-in. dia flange is offered with 1 through 10 hp. Totally enclosed, non-ventilated and fancooled construction is rated at 131 F. Available in normal- and high-torque, continuous- and intermittent-duty, single- and multi-speed designs. **Electrical Div, Fairbanks, Morse & Co, Freeport, Ill.**

Circle 329 on Reader Service Card



Servoassembly . . .

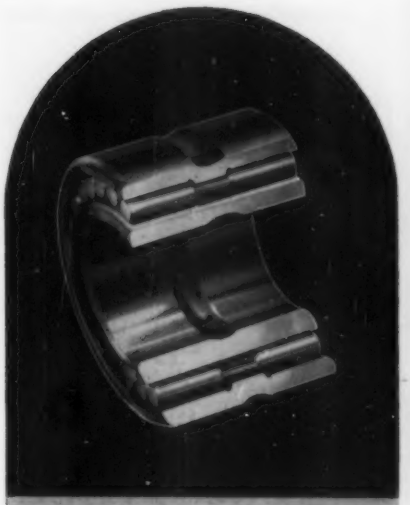
acting as a potentiometer, comprises a size 11 motor with 0.32 oz-in. torque and 3300 rpm speed at max power output of 0.81 w; size 11 speed reducer in ratios from 5.3:1 to 1267.7:1; and a 24 v, dc clutch which breaks potentiometer shaft when coil is deenergized. Drive from motor and gear head activates potentiometer when coil is energized. **Sterling Precision Corp, 5 Sintsink Dr, Port Washington, NY.**

Circle 330 on Reader Service Card

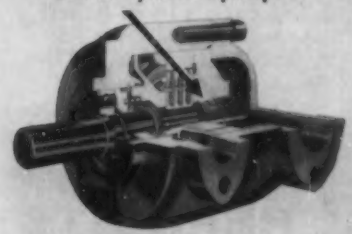
Ring-dynamometer transducer

changes a 400-lb load into a 1-lb load on load cell, which changes 20,000-ohm resistance with 0.001-in. deflection. Operates from a 1.5 v, dc supply at a current drain of 0.001 amp for full 400-lb load, indicating on meters, relays, or recorders

continued on page 102



GUIDEROL® compactness and high load capacity utilized in DENISON hydraulic pumps



The Denison Engineering Division of American Brake Shoe Company cites compactness, high load capacity and separable design as advantages of the McGILL GUIDEROL bearings which they use to carry externally applied loads in their "T" Series Balanced Vane Hydraulic pumps. Denison Engineering also state that they have benefited from "Good delivery and cooperation from McGILL Engineering on new development."

Typical applications of Denison "T" Series Balanced Vane Pumps are for continuous 2000 psi service in earthmoving equipment, and similar types of mobile equipment; special machinery, such as extrusion presses and in automation feed service and index mechanisms.

McGILL® GUIDEROL® BEARINGS
pack more capacity in less space

- *Center-guided rollers limit skewing tendency, prevent binding*
- *Integral seals increase life — avoid frequent relubrication*

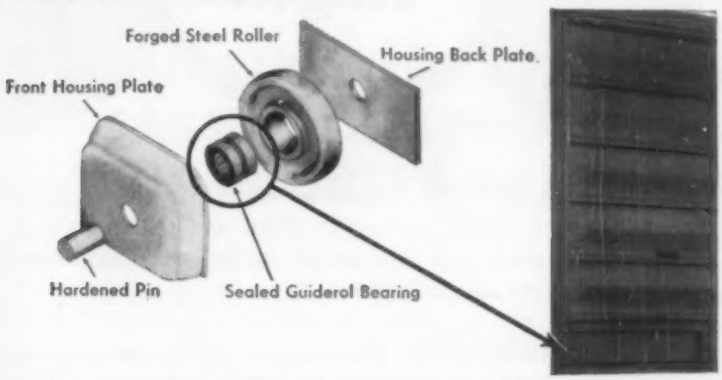
GUIDEROL bearings provide the maximum load carrying surface and minimum radial dimension advantages of full-type roller bearings — plus free and accurate tracking where misalignment is controlled. They are especially suited to vertical mounting. Sealed models keep out abrasive and lube-diluting contaminants — and avoid relubrication problems. These heavy duty units are available with or without inner races with bore sizes from ½" to 9¼". Typical applications and their advantages are shown below.

Integral seals protect operation of GUIDEROL® bearings in PULLMAN-STANDARD box car door rollers

Pre-lubricated and sealed GUIDEROL bearings are used in the door roller assembly shown here by the Pullman-Standard Car Manufacturing Company to assure ease of operation in spite of exposure to severe service conditions. Integral seals prevent infiltration of dirt and retain lubrication thus minimizing maintenance.

This roller arrangement was proved through test-application of over 75,000 severe individual roller and bearing impacts. Normal operation imposes loads of 600 pounds at 1.5 G's vertical acceleration.

Pullman-Standard also uses McGILL sealed GUIDEROL bearings in their P-S Compartmentizers, which consist of two pairs of strong steel gates dividing the box car interior into three flexible-size compartments. The gates roll smoothly on GUIDEROL bearing equipped rollers for easy, quick, one-man operation.



OLIVER tractors use GUIDEROL® bearings to provide long life

The Oliver Corporation employs a McGILL GUIDEROL bearing as the rear support for the power take-off shaft of its 660, 770 and 880 model tractors. The application is unusually demanding because of high fluctuating loads which may be applied by universal joints employed at an excessive angle, or by vee-belt or chain sprocket accessory drives. Oliver says the McGILL GUIDEROL has "long life, requires little maintenance, and will accept great loads." It operates at 540 rpm at a theoretical loading of 366 lbs. — greatly magnified by varying PTO attachments.

engineered electrical products

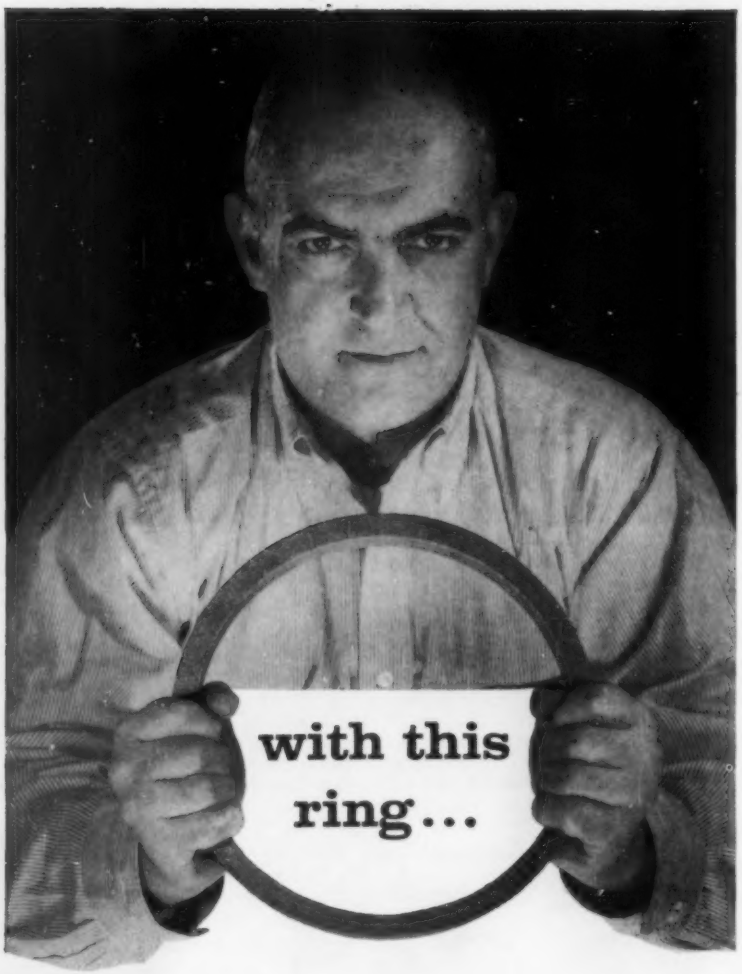
McGILL®

precision needle roller bearings

Send for free copy of McGILL Bearing Catalog No. 32-A.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
201 N. Lafayette St., Valparaiso, Indiana



the perfect match Edgewater Steel has the engineering experience, the manufacturing facilities and the know-how to produce solid steel rings that match perfectly the requirements of a wide variety of applications.

long-term reliability Our unique rolling process assures maximum reliability in terms of strength and toughness. What's more, the precise accuracy of this process minimizes finishing operations.

Edgewater ROLLED STEEL Rings Complete, modern rolling and finishing facilities enable us to provide a great variety of cross-section shapes in a wide range of sizes . . . from 5 in. to 145 in. in diameter. Our brochure gives complete details. We will be glad to send you a copy.

Edgewater Steel Company
P. O. BOX 478 DEPT. PE
PITTSBURGH 30, PA.

without amplification. Made of controlled heat-treated rings in both resistance and capacitance types. Available for forces up to 5000 lb. **Clark Electronic Laboratories**, Box 165, Palm Springs, Calif.

Circle 331 on Reader Service Card

Tiny strain-gage transducer... weighs 0.5 g and measures 0.59 in. dia x 0.050 in. thick. Available in absolute, gage or differential from 0-10 to 0-100 psi. Excitation is 15 v, and output is 5 milliv, full scale open circuit. Combined error due to non-linearity and hysteresis is said to be less than ±1% of full scale. Ambient temperature limits are —65 to 150 F. **Statham Instruments Inc**, 12401 W Olympic Blvd, Los Angeles 64.

Circle 332 on Reader Service Card

REPRINTS

Reprints currently available without charge are listed on the Reader Service Card bound in this issue. Single copy free; quantity prices on request.

The following special reports are available as long as the supply lasts, from Reader Service Dept., Product Engineering. 330 W 42nd St, New York 36. Please enclose remittance with order we pay postage.

R77—The New Mathematics $2
Combined reprint of 18 articles with coverage in depth on the latest math tools of systems engineering, 64 p.

R48—Reinforced Plastic Parts $2
Combined reprints of 11 articles giving design data on the seven processes for commercial parts, 64 p.

R69—Human Engineering $1.50
Series of 14 articles with design data on man-machine problems and human dimensions; plus bibliography, 44 p.

R76—Creativity $1
Combined reprint of 10 articles on the facts behind the fad. 32 p.

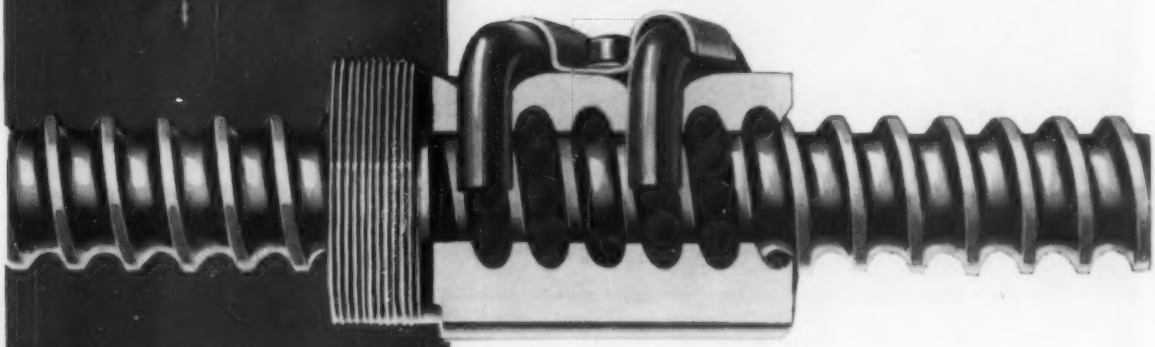
R66—The European Engineer Talks $1
The challenge to American proficiency in design from interviews with technical directors in six countries, 24 p.

continued on page 104

ACTUAL SIZE

MINIATURE Small enough to rest on the head of a tack, the newest and tiniest Saginaw b/b Screw is only ¾ of an inch long, has a B.C.D. of just 3/16ths of an inch. It solves positioning/control problems in telemetering and guidance systems and other diminutive applications.

GIANT-SIZED Giant Saginaw b/b Screws, built as large as 6 inches B.C.D. and as long as 40 feet, are used in applications where size reaches gigantic proportions. Proof of their versatile adaptability, Saginaw b/b Screws are used in boom hoists, telescoping blimp mooring masts and other applications.



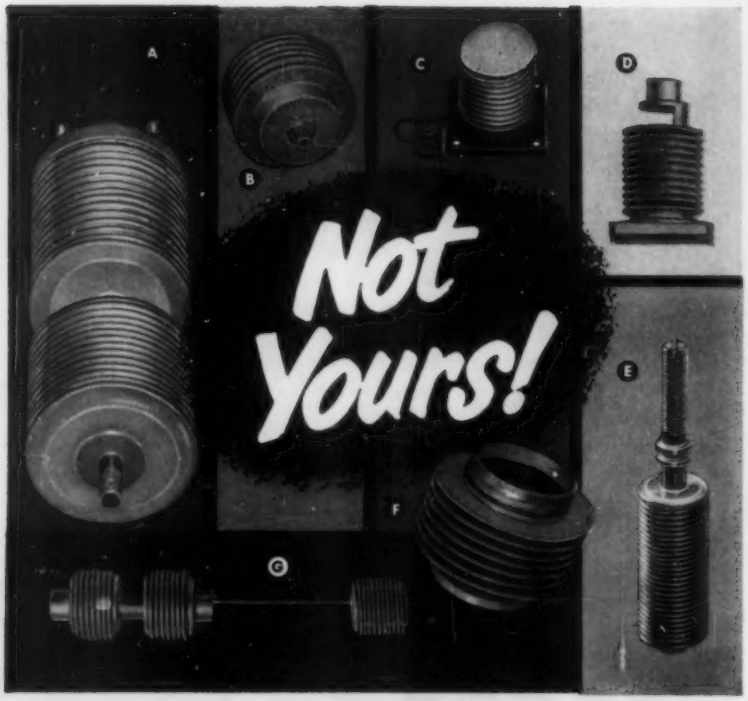
SAGINAW ball/bearing SCREWS CARRY YOUR PRODUCT'S SUPERIORITY FURTHER!

WRITE TODAY FOR Saginaw's new 1961 fact-filled Engineering Data Book.

The men who want to increase their product's maximum potential specify the remarkable Saginaw Screw for its many advantages. The 90%-plus efficiency of actuators using the ball bearing screw principle lowers operating costs, requires far less maintenance, simplifies design, in many instances reduces installation costs. Saginaw Screws are adaptable to electrical, hydraulic, mechanical or pneumatic operation. Their length and ball circle diameters can be built to almost any size. Their dependability and accuracy can improve your product's function and help make it more competitive!

Saginaw ball bearing Screw

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS CORP., SAGINAW, MICH.



If you're a bellows user, odds are high against one of these being yours: they're merely typical of the thousands of different types we've produced for almost every branch of industry.

Name your conditions of stress, atmosphere, temperature, vibration, pressure . . . tell us the flexibility, sensitivity, durability you need.

Backed by the most experienced know-how in the field, every Robertshaw Bellows is custom-engineered to do a particular job . . . and do it more efficiently, more economically.

Get the full story on Robertshaw Bellows and Bellows Assemblies . . . and some good, solid bellows background . . . in Catalog XP-R, FULTON SYLPHON DIVISION, ROBERTSHAW-FULTON CONTROLS CO., KNOXVILLE 1, TENNESSEE.

A. Brass aneroid assembly, ambient pressure compensation. Large bellows for added power and sensitivity.

B. Beryllium copper aneroid assembly for aircraft pressure controls. Highly flexible, durable, sensitive. Silver-brazed construction.

C. Pressure sensitive brass bellows with special end fittings.

D. Brass thin-walled bellows for extreme sensitivity and flexibility.

E. Liquid filled thermostatic assembly; pressure insensitive.

F. Seamless, stainless steel bellows; welding ends. For vibration isolation or misalignment; accommodates pipe movement on sealed systems.

G. Highly flexible brass bellows for aircraft; compensated for ambient pressure changes for absolute pressure response.

Robertshaw

MR. CONTROLS

REPRINTS .....continued

R16—Plate Cam Design $1
Series of 7 articles with complete design data; curve blending and profile synthesis to reduce inertia, 48 p.

R65—Reading, Writing, Reporting $1
Combined reprint of: 5 steps to faster reading: 8 steps to better writing: 7 steps to better reporting, 24 p.

R46—Manual of Reliability 50¢
How to design for reliability, human factors, statistical tools; implementing the program, 32 p.

R78—Ball Bearings 50¢
Performance of 50 commercial and precision types tabulated and compared, 16 p.

R41—Design by Digital Computers 50¢
How to choose and operate desk-size problem solvers, 12 p.

R22—Engineering Organization 25¢
Study of 50 companies shows changes in large and small companies, 24 p.

R21—Engineer's Bookshelf 25¢
Annotated bibliography of technical books for the design engineer, 24 p.

R75—Radiant Cooling 25¢
Design techniques and new emissivity data.

R74—Right-angle Gears 25¢
Detailed guide to all 16 available types.

R73—Digital Readouts 25¢
How they work; how to choose one.

R71—How to Design Nomographs 25¢
Simple step-by-step guide to best method.

R68—Encapsulating Systems 25¢
Comparison and selection of basic systems.

R67—Heat Protectors for Motors 25¢
Response and accuracy of inherent types.

R62—High-speed Photography 25¢
How it can solve design problems.

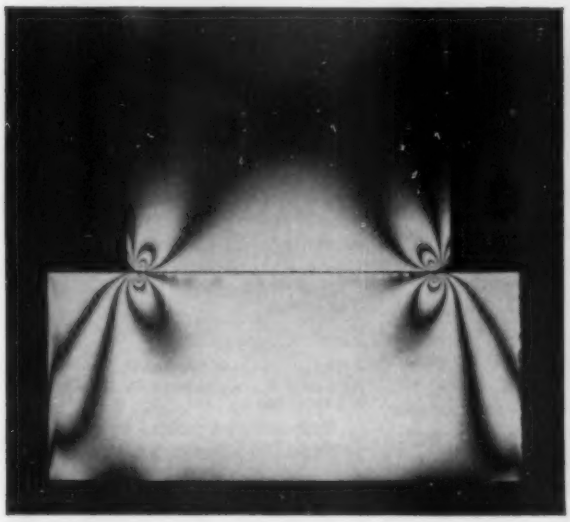
R53—Significance of WK² 25¢
Selecting Motors for high inertia loads.

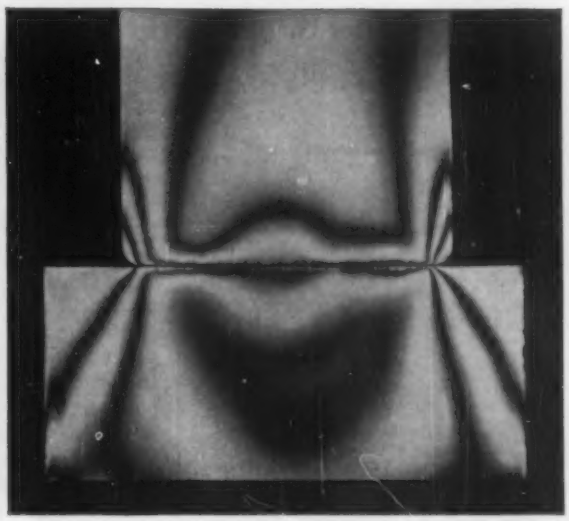
"We start the year with problems—the same ones that we didn't solve last year!"

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

* * * *

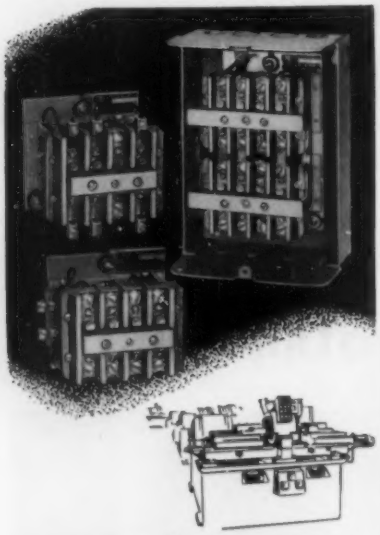
Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

CIRCLE 105 ON READER SERVICE CARD

Here are rugged, reliable
COMPACT CONTACTORS
for high capacity service!



B|W

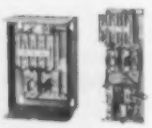
Industrial and Motor
CONTROLS

Take a good look at the B/W line of magnetic and reversing contactors and you'll get a refreshing new concept of motor control quality and value.

☐ They're small in size—simple, straightforward in design—easy to wire—and ruggedly built to give you reliable, long-life service on a wide range of high capacity control applications. All contacts are vertically mounted up front. Built-in return springs provide fast, positive breaks. Armatures travel in a straight predetermined plane to assure proper seating, quieter operation. Available in low-cost horsepower and ampere rated models to meet your special application requirements.

Other Reliable B/W Electrical Control Components

Induction Type & Electronic Relays



Magnetic Starters & Combination Starters

Custom Engineered Control Panels

Push and Pull Type A. C. Solenoids

Complete technical data available upon request—write today!

THE B|W CONTROLLER CORPORATION

2200 E. MAPLE ROAD • BIRMINGHAM, MICHIGAN

Manufacturers of Liquid Level and Industrial Motor Controls

DESIGN LITERATURE

Power to Produce

The Yearbook of Agriculture, 1960; Alfred Stefferud, editor US Dept of Agriculture. Available from Supt of Documents, US Government Printing Office, Washington 25, DC. 5½ x 8½, 440 pp. $2.25.

The importance of the USDA yearbooks put out by Alfred Stefferud, his contributors and copy readers, is not only in what they say but how they say it. Here is little of that gobbledygook that has given Washington a bad name. Specifically, these yearbooks demonstrate that the language of science and technology can be usefully clear and interesting—without sacrificing accuracy.

Previous yearbooks have focused on such phases of farming as genetics, agronomy, chemicals. The 1960 volume spans the field of power as it applies to the aspects of today's mechanized farming. This book is for the farmer and the agricultural researcher; it is also for engineers who want to develop new methods and equipment that will catch the interest of the farmer (or his marketing organization)—the kind of tractor clutch or egg conveyor he wants; the hyperbolic paraboloid that shapes the roof of his new turkey porch; the special gadgets such as tenderometer, fibrometer, succulometer. The book even remembers to bring in the transistors and computers now used to give him phone service and plan his electric power.

With the usual capable prose go the USDA's usual instinct for the right photos and sketches. The 61 papers by researchers and engineers are grouped into nine main sections: Power in the Past; Power in the Present; Power on the Land; Power in the Harvest; Power in the Market; Power and Efficiency; Power and Its Effects; Power in the Future.

—WG

Analog Computation in Engineering Design

A E ROGERS, T W CONNOLLY. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6¼ x 9¼, 450 pp. $16.

A practical text for engineers who wish to make the most of present analog computing machinery. The emphasis is on application of the machines, rather than on their design or operation. The book includes an introduction to the general-purpose computer, its elements, capabilities and limitations; a detailed analysis of the kinds of problems and types of equations it will solve; and a study of many typical real problems taken from a variety of industries. The authors review conventional, paper-and-pencil solutions of problems in higher engineering mathematics before describing the computer approach to those problems. Of particular interest is the consideration of problems involving statistical phenomena and the special methods for solving partial-differential equations, algebraic equations and nonlinear systems. The adjoint method is presented in practical terms. Author Rogers is a member of the staff of Electronics Associates Inc, and Mr Connolly, now with Sperry Rand Corp, was previously employed by Electronic Associates Inc.

Book Computer

Published by (and available from) Metron Instrument Co, 432 Lincoln St, Denver, Colo. 8 x 10¼, 900 pp. $15.

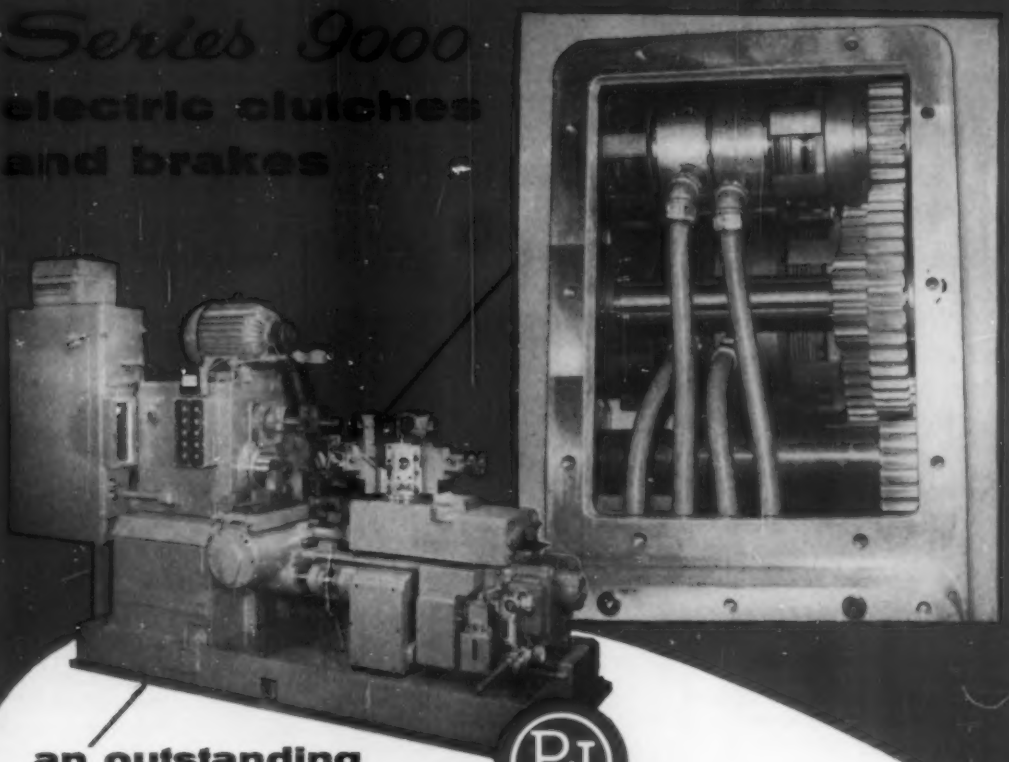
Authored and printed by computer, this is a complete multiplication table for any pair of three-digit numbers (100×001 to 999×999). It can be used either for multiplication or division. Page numbers serve as one factor; the other is found on the page in numbers from 001 to 999. Opposite the second factor is the six-digit product. Division is performed by working backward to give a three-digit quotient. Numbers of less than three digits can, of course, be multiplied by manipulating the decimal point. Numbers greater than three digits can be multiplied by splitting them into several parts and making a pencil-and-paper addition: $471{,}943 \times 931{,}168 = (471{,}000 + 943) \times (931{,}000 + 168)$.

Faster than log tables, slower than a sliderule or desk calculator, it may be found particularly valuable for some specialized kinds of computing. However, the type is small, being photo-offset directly from the actual computer output with perhaps a 2 to 1 reduction. At the bottom of each page is the square, cube, square root, cube

continued on page 109

Maxitorq

Series 9000 electric clutches and brakes



an outstanding design feature of tape-controlled automatic turret lathes

Five Maxitorq Series 9000 Electric Clutches are used in the all-new Potter & Johnston No. 3E-15 Tape-Controlled Automatic Turret Lathe. Four are used in the headstock to provide automatic spindle speed changes and a fifth is used as a master clutch in the feed drive. These clutches of advanced design have PROVED their ability to assure consistent, positive and extremely fast action; essential to these machines. They transmit full load, are self-compensating for wear and permit great flexibility in control.

With operation induced entirely by magnetic flux, Maxitorq Series 9000 Electric Clutches are well adapted to a wide range of machine tool drives. They are simple and rugged in design, require no adjustments, can be used *either as a clutch or brake* and are built to American Machine Tool Standards. Disc separators not only separate discs, providing a drag-free neutral without heating, but also break up residual magnetism and permit extremely fast, positive action.

The 9000 Series Clutches have a minimum of moving parts and the electrical operating unit remains stationary, hence, there are no brushes, slip rings or complex wiring. Maxitorq Clutches operate on 110 V. A. C. rectified to 90 V. D. C. Other voltages on special order.

If you have a clutch or brake application where you are looking for new and improved performance, bring your problem to us.

Phone, wire or write Dept. PE for Series 9000 Bulletin.

The Carlyle Johnson Machine Company, Manchester, Conn.

CIRCLE 107 ON READER SERVICE CARD 107

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of "blind hole" joints

Holes which don't go all the way through a solid member must be tapped, of course. In shallow, small holes, in non-critical fastening, and in soft materials thread cutting screws work well and save time.

But fastening large flanges, pressure plates, heads and the like to costly castings needs more precise production. These holes are ¼" diameter and larger, affect design strength.

THREAD EFFECTS

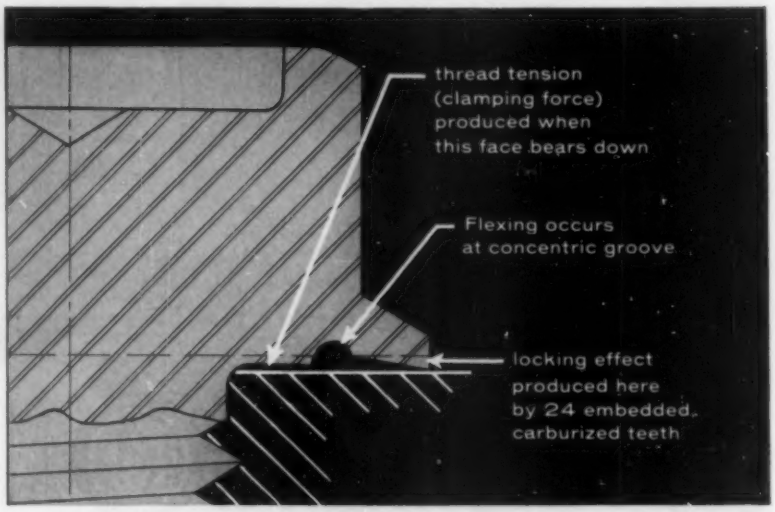
Such holes are coarse threaded. The coarse threads develop more thread strength than do fine threads, also take fewer turns in assembly. Studs go into the holes with an interference thread fit; hex screws with a simpler clearance fit.

Desirably, studs should all be driven to same depth and bottomed. Because of normal manufacturing differences, various mismatched high and low tolerances will cause studs to project unevenly. Assemblers often have to juggle. No such problem exists with hex screws. You just tighten to specified preload. And there's no double driving operation, as with stud plus nut.

STRENGTH OF BLIND JOINTS

Tapped holes behave like nuts. Their threads adjust elastically and plastically to distribute stress and develop high thread tension. Is this harmful in repeated disassemblies? Not at all. Hex screws have been installed 50 times in cast iron test blocks, then tightened to failure without damage to tapped holes.

Clamps like a hex screw Grips like an anchor


thread tension (clamping force) produced when this face bears down
Flexing occurs at concentric groove
locking effect produced here by 24 embedded, carburized teeth

Tensilock® screws offer you the ideal combination of high clamping force and high locking power.

While a standard high strength hex screw can be tightened to a higher thread tension, its off-torque is less than its on-torque.

ANCHORED IN PLACE

The *"Tensilock"* screw features ratchet action teeth formed at an angle which will cut driving effort to permit you to utilize more of the full strength of screw. At equal driving torque, it not only develops 90% of the strength of a high strength hex screw but also takes *25% more torque to loosen than to tighten.*

Because of the flange's concentric groove, it flexes, allows the screw to bear down solidly on its seat and develop a high level of thread tension. At the same time the teeth embed themselves, are aided in maintaining their grip by pressure of the spring-action flange.

MAKES GOOD FRICTION-TYPE JOINT

Clamping force from Tensilock fasteners is sufficient to prevent slippage of fastened members where holes are oversize or eccentric. Grip of the teeth keeps fasteners tight under conditions of vibration or cyclic temperature changes. RB&W *"Tensilock"* Nuts also available. Write for Bulletin TL-2. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

® Registered and Patented

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

root, reciprocal, logarithm, area and circumference of circles for the factor indicated by the page number.

Rolling-contact Fatigue Life

NASA TR R-60. Thomas L Carter. Superintendent of Documents, Government Printing Office, Washington, DC. 8 x 10¼, 48 pp. 50¢

A rolling-contact fatigue spin rig was used to evaluate the effect on rolling-contact fatigue life of the following factors: stress, forging-fiber orientation, lubricant viscosity, lubricant-base stock, temperature, dry-powder lubricants, metallurgical structure, and alloy composition. Ball specimens of ½- or ⅝-in. dia were tested at loads producing maximum theoretical Hertz compressive stresses of 600,000 to 750,000 psi. Results reported indicate that each factor studied had a definite effect on rolling-contact fatigue life. Full title: A Study of Some Factors Affecting Rolling-contact Fatigue Life."

Other Books of Interest

An Evaluation of Some Current Practices for Short-time Elevated-temperature Tensile Tests of Metals

NASA Technical Note D-420. C R Manning Jr, G J Heimerl. National Aeronautics and Space Administration, Washington 25, DC. 8 x 10¼, 44 pp. $1.25.

Stress-corrosion Cracking of Austenitic Chrome-nickel Stainless Steel

ASTM Publication 264. American Society for Testing Materials, 1916 Race St, Philadelphia 3. 8½ x 11, 92 pp. $6 nonmembers; $4.80 members.

Explosive Forging

PB 161457. Vasil Philipchuk. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, approx 50 pp. $1.75.

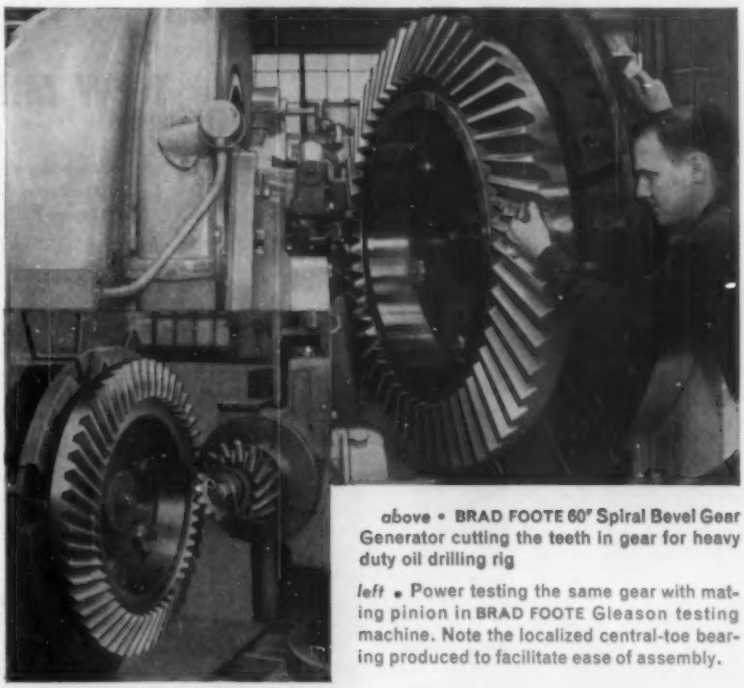
continued on page 111

"We've got an incentive program that really works."

BRAD FOOTE gears ...FOR A WORLD AT WORK

SPIRAL BEVEL GEARS

for precision mechanisms and heavy duty power transmission



above • BRAD FOOTE 60" Spiral Bevel Gear Generator cutting the teeth in gear for heavy duty oil drilling rig

left • Power testing the same gear with mating pinion in BRAD FOOTE Gleason testing machine. Note the localized central-toe bearing produced to facilitate ease of assembly.

BRAD FOOTE offers the finest cutting and testing equipment available for the production of precision spiral bevel gears in the widest range of capacities.

These include such diversified drives as: spiral, zerol, right angle, obtuse or acute angle. They may be in sizes from 1" to 60" diameter, 10 DP to 1 DP and from ½" face to 10" face.

For precision mechanisms or heavy duty power transmission, BRAD FOOTE builds your gears from blanks to finished product...fills all your requirements from one source.

ORDER FROM BRAD FOOTE

Your order for BRAD FOOTE Gears will be processed by an experienced organization of gear specialists and produced on the most extensive and versatile facilities available. Maximum performance and your complete satisfaction are assured because no one shares our responsibility.

OTHER BRAD FOOTE SPECIAL EQUIPMENT INCLUDES: High Precision Rack Broaching Machine with capacity up to 1 DP; 154" Precision Gear Shaper; 72" Diameter Shaving Machine

MEMBER OF AGMA

BRAD FOOTE GEAR WORKS, INC.

1315 South Cicero Avenue • Cicero 50, Illinois • Bishop 2-1070 • OLympic 2-7700

subsidiary • PITTSBURGH GEAR COMPANY, Neville Island • Pittsburgh 25, Pa., Phone: SPaulding 1-4600

Select from over 3,500 different SOLENOID VALVES from VALCOR

Series SV-54 (3 way-4 way) general purpose solenoid valves for air, oil and water. Rugged construction, yet inexpensive. Multi-million cycle life. Pressure ratings up to 150 psi. Nylon seat outlasts steel. Infinite varieties available . . . lists as low as $10.75.

Series SV-61 (2 way) Nylon body valve is ideal for general purpose and OEM installations where millions of operating cycles are vital. Nylon seat and port threads outlast steel, yet cost less. Non-corrosive, shock-resistant, proof-pressure.

Series SV-5100 Specifically designed to handle the most corrosive media in industry. Manufactured in Teflon, PVC and Nylon varieties. Diaphragm construction prevents media contact with any metal. Available in direct-acting or piloted models.

VALCOR SOLENOID VALVES

FREE . . . new 16 page brochure —lists over 500 corrosive media—coded for correct valve selection.

For complete information on these or other models, write or call:

VALCOR ENGINEERING CORP.
5375 Carnegie Ave., Kenilworth, N. J.
CHestnut 5-1665

DESIGN TIMING RELIABILITY INTO YOUR CIRCUITS *specify . . .*

NEW MINIATURE AGASTAT®

time/delay/relays

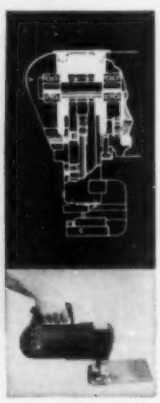
- **Recycling virtually instantaneous—less than .020 seconds**
- **Unaffected by Voltage fluctuations (from 18 to 32 volts DC)**
- **Repeat Accuracy ±5%**

This new AGASTAT meets the environmental requirements of MIL-E-5272A. Built to withstand the rugged conditions of missile and aircraft applications. Lightweight—less than 15 ounces. Space saving—4⅝" tall . . . 1 13/16" wide . . . 1½" deep. Adjustable, with time delays from .030 to 120 seconds. Choice of operation for energizing or de-energizing. For complete specifications, write Dept. A37-1226.

AGASTAT TIMING INSTRUMENTS
ELASTIC STOP NUT CORPORATION OF AMERICA
1027 NEWARK AVENUE, ELIZABETH 3, NEW JERSEY
CIRCLE 204 ON READER SERVICE CARD

CUT ¼ INCH STEEL PLATE EASILY AND IN ABSOLUTE SAFETY *with the* **FENWAY heavy duty NIBBLER**

MODEL EHN



The new, lightweight Fenway ¼" Nibbler cuts through ¼" cold or hot rolled steel plus 5/16" aluminum, quickly and easily. Also cuts 8 gauge stainless. Its special design provides absolute safety to the operator and will cut without distortion to material. Clean cutting action reduces need for grinding and buffing edges. Has minimum cutting radius of 8". Weighs only 20 lbs. SEND FOR COMPLETE SPECIFICATIONS OR ASK FOR FREE DEMONSTRATION IN YOUR AREA.

Other Fenway Nibblers are available for a variety of cutting jobs . . . help reduce costs as much as 75%.

FENWAY MACHINE CO., INC.
1910 N. Marshall St. Phila. 22, Pa.

An Investigation of the Mechanical Properties of Cermets as Related to the Microstructure

PB 161656. Ira Binder. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 10¾, 88 pp. $2.50.

Thermoelectricity Abstracts

PB 161301. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 114 pp. $2.50.

Includes references from current periodicals and research reports. This is the third volume in a series and includes some of the literature published in 1959.

Symposium on Newer Metals

ASTM Publication 272. American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9¼, 218 pp. $7.25.

Contains material on refractory, nuclear and light metals.

ABSTRACTS FROM THE LITERATURE

Temperature Controllers

This article identifies the operating principles of the various types of controllers used in heated equipment. Each type has advantages and limitations that influence its performance in specific applications, and a familiarity with these principles will guide the designer in making a sound selection for his particular problem. Three types of controllers are: expanding metal, expanding fluid (liquid, gas or vapor), electronic.

"How to Select the Right Temperature Controller," by Robert G. House, Fenwal Inc. Design Engineering, Oct '60, 481 University Ave, Toronto 2, Canada.

Failures in Weldments

Failures in weldments caused by both fabrication and service conditions are discussed. Such factors as laminations, surface carburization and decarburization, mechanical notches, material selection, joint fitup, weld-metal condition, welding procedure, stress, corrosion and other service factors are included.

"Weldment Failures Caused by Fabrication and Service." Helmut Thielsch, Grinell Co. Welding Journal, Nov '60, 33 W 39th St, New York 18.

Lubricating Hot Metal

Classifies fundamental processes in high-temperature lubrication from 100 F to 1700 F. By investigation of the numerous simultaneous processes occurring in lubricated systems

continued on page 113

brazing washers Edgewound

FROM WIRE STOCK

- No lead time needed for dies or exact strip.
- Use with induction, gas-air, furnace, or other heating methods.
- Available in EASY FLO and SILFOS — Copper, Bronze, and other alloys.
- Diameters up to 4" I.D., wire thicknesses from .010 upward.

No die charges
No blanking scrap losses

Write for 16 page booklet on better brazing.

LUCAS-MILHAUPT Engineering Co.
5060 South Lake Drive, Cudahy, Wisconsin
CIRCLE 206 ON READER SERVICE CARD

Mono Cord

NO SPLICE RINGS

are better because the principle hazard found in ordinary seal rings and belts has been removed by Western's *Mono Cord* one-piece construction. In addition, dimensional requirements are maintained, quality controlled, and service vastly improved—all at no extra cost.

Don't use a spliced ring for technical seal applications, but profit from nearly 60 years experience—specify *Mono Cord* rings by Western.

Write or phone for information, literature or a visit by our sales engineer in your area.

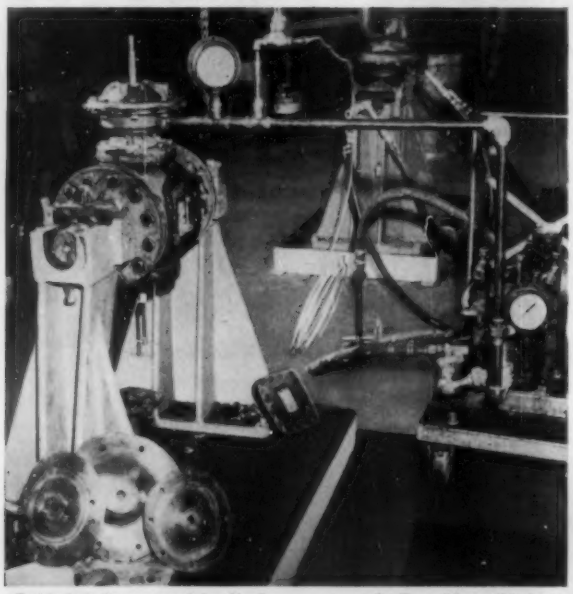
Mono Cord

SINCE 1902

WESTERN RUBBER CO.
GOSHEN 9, INDIANA

Molded and Lathe-Cut Rubber Parts for All Industries

DIAPHRAGM OF REEVECOTE WITHSTANDS 23,520 LB. THRUST IN SAFETY TEST



Safety tests for gas regulator diaphragms are run by Reynolds on this device fed by a hydraulic pump. Here, on an effective area of 24 sq. in., a Reevecote synthetic diaphragm safely absorbed a total thrust of 23,520 lbs.

The Reynolds Gas Regulator Co., of Anderson, Ind., takes unusual safety precautions to check the tensile strength of diaphragms in their gas regulators.

Some of their diaphragms must absorb sudden surges in pressure—up to 1000 psi. That's why Reynolds runs special safety tests on the diaphragms.

The results of these tests prove the outstanding superiority of diaphragms made of Reevecote.

In a recent test at Reynolds, Reevecote 7270, 0.093" gauge a Buna-N coated nylon, successfully withstood 980 psi on an effective diameter of 24 sq. in.—or a total thrust of 23,520 pounds.

Reevecote diaphragms are flexible and sensitive, yet tough enough to stand up safely under severe extremes of pressure.

If your design calls for the use of diaphragms, or coated fabrics—choose from the most complete source of coated fabrics for industry—REEVECOTE.

REEVES VULCAN

Reeves Brothers, Inc., Vulcan Rubber Products Division
1071 Avenue of the Americas · New York 18, New York

New...from MARSH!

Small solenoid valves that fill a BIG order

MARSH Master-mite SOLENOID VALVES

Conduit-type Master-mite. Grommet-type also available.

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes:
3/64" through 1/4".

Wide range of voltages:
Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A.C.

Pressure to 540 psi.

Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

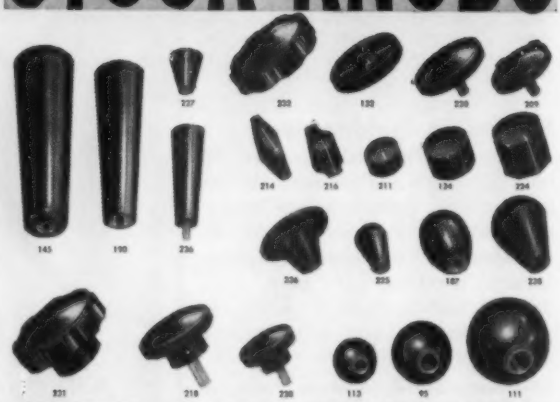
Write for new bulletin

MARSH INSTRUMENT COMPANY
Dept. 39, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

CIRCLE 207 ON READER SERVICE CARD

STOCK KNOBS

...NO TOOLING CHARGE!



Wide selection molded plastic knobs, handles, hand-wheels at no tooling charge! Minor changes (inserts, threads, color, etc.) to suit requirements. Other modifications give your part a look of exclusive design at fraction of new mold cost! Write for complete illustrated catalog, or see Sweet's Product Design Catalog File.

DIMCO-GRAY COMPANY
206 EAST SIXTH STREET • DAYTON 2, OHIO

CIRCLE 112 ON READER SERVICE CARD
CIRCLE 208 ON READER SERVICE CARD

at high temperatures, it is possible to elucidate many of the complex relationships between friction and temperature. However, since two or more processes may function in an synergistic manner and other mechanisms may operate in an opposed or adverse way, the friction-temperature relationships are indeed complex. The techniques for the further study of these fundamental processes related to friction and wear have been indicated.

"Fundamental Processes in Lubricating Metal Surfaces at 100 F to 1700 F," by E. N. Klemgard, Washington State University. Lubrication Engineering, Oct '60, 5 North Wabash Ave, Chicago 1.

Glossory of Reinforced Plastics

Gives explanations, definitions of some 90-plus terms commonly used in the reinforced-plastics industry.

"Glossary of Terms Used in the Reinforced Plastics Industry," Arthur Smith, Rohm & Haas Co. SPE Journal, Sep '60, 65 Prospect St, Stamford, Conn.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

MAN-MADE FIBERS—Pocket-size guide, 71 pp. Contains FTC fiber definitions, physical and comparative properties, end-use applications, trademarks and producers of 16 generic fiber classifications. Includes denier conversion tables and glossary of textile terms. American Viscose Corp, 1617 Pennsylvania Blvd, Philadelphia 3.

Circle 350 on Reader Service Card

HYDRAULIC ROTARY ACTUATORS —Catalog, 16 pp. Details operation, specifications, mounting information, spline

continued on page 115

"This makes six boys."

CIRCLE 113 ON READER SERVICE CARD →

NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**

Precision Series "A" and Low Cost Series "B" BALL BUSHING

Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

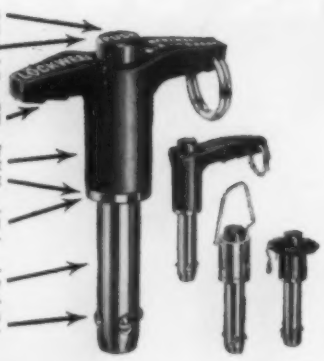
LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. H, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

Let LOCKWELL® solve your quick release pin problem...the quality way.


Large diameter release button allows arctic glove operation.
Red release button: suggests caution — locates button.
Grip-well handles with optimum operational clearances.
Handle independent of steel shoulder—does not contribute to holding power of pin.
Steel shoulder for maximum wear qualities and greater tension capability.
Maximum strength-weight ratio and quality construction throughout.
4 ball safety lock gives superior tension properties.

LOCKWELL® QUICK RELEASE PINS

LOCKWELL PINS are the quality answer for a quick release fitting where safety, speed of removal and dependability are of paramount importance.

Write today for complete information

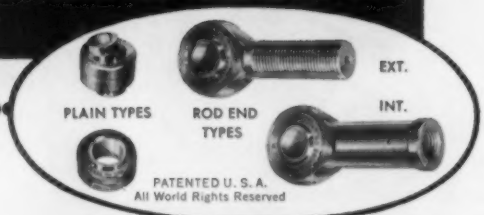
THE HARTWELL CORPORATION

9035 VENICE BOULEVARD, LOS ANGELES 34, CALIFORNIA

Offices: Chicago • Ft. Worth • Hackensack • Seattle • Wichita

CIRCLE 209 ON READER SERVICE CARD

SOUTHWEST "Monoball" SELF-ALIGNING BEARINGS



CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.
4	"Dyflon"® Plastic Alloy Inserts. CRES Ball and Race. Chrome Alloy Steels.	For types operating under rotational, high radial loads and long cycle life where lubrication is impossible.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Our engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. Write for Engineering Manual No. 551. Address Dept. PE-60.

SOUTHWEST PRODUCTS CO.

1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

WARRICK

Floatless, Electrode Type

LIQUID LEVEL CONTROLS

give you all these advantages!

No moving parts in the liquid • Easy to install • No adjustments necessary • Unaffected by acids or caustics • Unaffected by pressure or temperature • Standard 2&3 pole units listed by U/L

Write for 32-page Catalog which gives complete specifications

Two pole control shown at left

YOU CAN USE OUR CONTROLS FOR:

- Single & multiple pumps
- Motor & solenoid valves
- High & low cutoffs & alarms
- Sewage & waterworks
- Chemical Industries
- Food & Dairy Industries
- OEM applications

Special controls to custom requirements

CHARLES F. WARRICK CO.

1964 W. Eleven Mile Road, Berkley, Michigan

Dept. 3 Telephone JOrdan 4-6667

CIRCLE 210 ON READER SERVICE CARD

MULTIROLL FILES

TRACINGS

PRINTS • SHEET MATERIAL

QUICK, FILING AND WITHDRAWAL

Depth	11¼"	22¼"	30½"	36½"	42¼"
49 Tube 1¾" I.D.	49AB $7.50	49CD $9.50	4930 $12.80	4936 $13.80	4942 $14.80
MODEL 25 Tube 2¼" I.D.	25AB $7.00	25CD $9.00	2530 $11.80	2536 $12.80	2542 $13.80

Shipping Weight

Model 49	8 lbs.	12 lbs.	15 lbs.	18 lbs.	20 lbs.
Model 25	6 lbs.	10 lbs.	13 lbs.	15 lbs.	17 lbs.

ENAMELED DARK GREEN OR MED. GRAY - State Color

JR 36

Designed to Mount Under Board—Mounting Brackets Furnished. Gray Only.

9.50 SET of TWO

Sold in Sets Only— 2 JR36 Per Set

8 lbs. Shp. Wt.

• SOLD DIRECT ONLY Write to Dept. BP

F. O. B. St. Clair Shores, Mich. • PRescott 3-2515

ROLL & FILE SYSTEMS, INC. P. O. BOX 3863 S DETROIT 5, MICH

CIRCLE 211 ON READER SERVICE CARD

CIRCLE 114 ON READER SERVICE CARD

data, and performance characteristics of five sizes with torque range from 1500 to 702,000 in.-lb at 3000 psi. Contains dimensional drawings and data, and internal leakage-vs-pressure curve. Houdaille Industries Inc, Dept II, 537 E Delavan Ave, Buffalo 11.

Circle 351 on Reader Service Card

MINIATURE CLUTCHES AND BRAKES—Brochure, 4 pp. Graphically illustrates performance characteristics of magnetic dry-particle types. Contains specifications and dimensional drawings. Technology Instrument Corp, 531 Main St, Acton, Mass.

Circle 352 on Reader Service Card

ACCELERATION SWITCHES—Data sheet, 2 pp. Covers specifications and physical characteristics of eight models of damped-type switches. Instruments Div, W L Maxon Corp, 475 10th Ave, New York 18.

Circle 353 on Reader Service Card

HYDRAULIC AND CIRCULATING SYSTEM OILS—Bulletin 66, 1 p. Lists physical properties and recommends uses for 11 straight-distilled oils with viscosities from 55 SSU at 100 F to 140 SSU at 210 F. Sun Oil Co, Industrial Products Dept, 1608 Walnut St, Philadelphia 3.

Circle 354 on Reader Service Card

ALLOY STEEL CASTINGS—Bulletin 300, 4 pp. Discusses chemical composition; tensile and elevated-temperature properties; and impact- and atmospheric corrosion-resistance of low-carbon, quenched-and-tempered constructional alloy steel. Also provides welding and machining data. Alloy Steel & Metals Co, 1848 E 55th St, Los Angeles 58.

Circle 355 on Reader Service Card

continued on page 116

"I'm Mrs. Twigg. As a result of a little discussion he and I had, we're trading jobs this week."

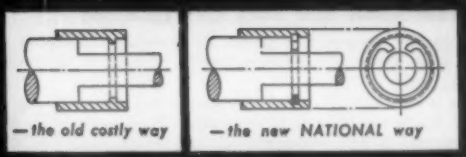
SAVE ON MATERIALS...

NATIONAL RETAINING RINGS

– improve products and cut costs substantially!

SAVE ON LABOR...

Efficient and economical NATIONAL Retaining Rings reduce weight, save space, simplify assembly and reduce production operations. Elimination of machining to form shoulders, threading, nuts and cotter pins are typical savings that can be effected. Ask NATIONAL for complete information and data on your particular applications, now!



FREE SAMPLES

And descriptive literature will be sent promptly on request. Call or write to National, today.

The NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN

CIRCLE 212 ON READER SERVICE CARD

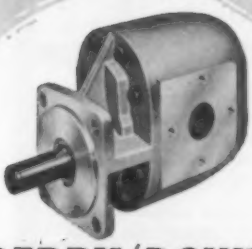
NEW Maximum Performance GEAR PUMP

Speeds to 2800 RPM

Temperatures to 250° F with min. 55 SSU

Pressures to 2250 PSI continuous

Flow rates to 60 GPM



BERRY/DOWTY GPA3 Series

- Designed for operation at mobile equipment engine speeds
- Can be direct-connected, gear driven or belt driven
- Conforms to SAE standards

Berry HYDRAULICS

A DIVISION OF THE OLIVER TYRONE CORPORATION

MAIL FOR COMPLETE DATA

Berry Hydraulics
Corinth 1, Miss.

Name_____

Company_____

CIRCLE 115 ON READER SERVICE CARD

EMPLOYMENT OPPORTUNITIES

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

Positions Vacant | Civil Service Opportunities | Employment Agencies
Positions Wanted | Selling Opportunities Wanted | Employment Services
Part Time Work | Selling Opportunities Offered | Labor Bureaus

DISPLAYED ——RATES—— **UNDISPLAYED**

The advertising rate is $37.00 per inch for all advertising appearing on other than a contract basis. Frequency rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

$2.10 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.
Position Wanted Ads are ½ of above rate.
Box Numbers—counts as 1 line.
Discount of 10% if full payment is made in advance for 4 consecutive insertions.
Not subject to Agency Commission.

Send NEW ADS to Classified Advertising Div. of PRODUCT ENGINEERING, P.O. Box 12, N.Y. 36, N.Y.

ADVANCED DEVELOPMENT
HIGH-SPEED CAMERA MECHANISMS

DESIRABLE SUBURBAN NEW YORK CITY LOCATION

We are seeking 2 highly creative mechanical engineers for extremely challenging positions. We are a stable, non-military, and rapidly-expanding division of a prominent national corporation.

These men will be engaged in the invention and development of complex mechanical and electro-mechanical products, involving high-speed gearing and linkage mechanisms, paper transports, automotive drives, and optical instruments.

1. **One SR. DEVELOPMENT ENGINEER, with about 10 years experience, including some supervision. Salary approx. $13,000**
2. **One DEVELOPMENT ENGINEER, with about 6 years experience. Salary about $9,500.**

Forward complete resume including salary requirements in confidence to:

BOX P. E. 1369, 125 W. 41st St., NYC

PRODUCT DEVELOPMENT MANAGER

Excellent opportunity for mechanical engineer to manage Product Development Department consisting of several engineers and model makers.

Candidates should have a successful background in the design and development of small mechanical consumer products or components for high volume mass production.

To be responsible for the development and improvement of new and existing products.

Send resume including salary information to Walter Evans.

GILLETTE SAFETY RAZOR CO.

Gillette

Gillette Park, Boston 6, Mass.

WANTED:
CREATIVE DESIGN ENGINEERS
(M.E.'s, E.E.'s, etc.)

Managerial and staff positions available for individuals combining experience, training or motivation in industrial design (imaginative, inventive, artistic approach to function, form, cost, marketability) plus product R&D engineering. Send resumes in strict confidence to

THEODORE S. JONES & CO.
(Specialists in Designer Placement)
Box 41Z Milton 87, Mass. Tel. OX-6-3221

DESIGN STYLIST

Position requires experience in styling product designs. Preferably in office furniture and equipment field. Well established company in Ohio. Send detailed resume and salary requirements to

P-5718, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

POSITION VACANT

Wanted—Graduate Mechanical Engineer experienced in steam trap, temperature regulator and heating specialties design and field amplification. Experience in heating processes and power piping knowledge desirable. Location—Eastern Middle Atlantic States. P-5721, Product Engineering.

When Answering
BOX NUMBERS . . .

to expedite the handling of your correspondence and avoid confusion, please do not address a single reply to more than one individual box number. Be sure to address separate replies for each advertisement.

DESIGN LITERATURE.....continued

TITANIUM TUBING—Data memorandum 27, 3 pp. Tabulates chemical composition, physical and mechanical properties and size limits for seamless tubing made from unalloyed titanium and 3% aluminum, 2.5% vanadium–titanium alloy. Describes heat treatment and welding of metal and alloy. Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.

Circle 356 on Reader Service Card

MULTIPLE CONNECTORS—Folder, 6 pp. Traces electrical and mechanical characteristics of pin-and-socket type. Describes and illustrates five types of screw-machined and formed contacts, connector shells and inserts. Explains compression-crimp technique for connecting contact to end of wire. Amp Inc, Harrisburg, Penna.

Circle 357 on Reader Service Card

PLASTIC LENSES—Bulletin 100, 4 pp. Discusses advantages, specifications and applications for plano-concave, plano-convex and cylindrical types. Fostoria Corp, Applied Products Div, Dept 90, Buck & County Line Rds, Huntingdon Valley, Penna.

Circle 358 on Reader Service Card

TITANIUM ALLOY—Manual, 11 pp. Outlines forging and heat-treating procedures for alloy and tabulates its creep, stability and fatigue properties. Titanium Metals Corp of America, 233 Broadway, New York 7.

Circle 359 on Reader Service Card

DIALLYL PHTHALATE RESIN MOLDING—Booklet, 27 pp. Describes molding requirements of compounds based on resins and tabulates physical and electrical properties, chemical and fungus resistance and flameproofing. Discusses effect of various mineral and synthetic fillers on molded properties. Food Machinery & Chemical Corp, Dapon Dept, 161 E 42nd St, New York 17.

Circle 360 on Reader Service Card

DIGITAL TIMERS, COUNTERS—Bulletin 98, 2 pp. Lists specifications for three- and four-digit models, and includes typical wiring diagrams. Chrono-log Corp, Box 4587, Philadelphia 31.

Circle 361 on Reader Service Card

SQUIRREL-CAGE INDUCTION MOTORS—Bulletin 6100.1, 8 pp. Outlines design features, performance characteristics and size range of open, protected motors. Lincoln Electric Co, Cleveland 17.

Circle 362 on Reader Service Card

STOPWATCH GUIDE—Catalog, 16 pp. Illustrates and provides specifications on construction, method of operation, size and reading for over 100 special purpose

and split-second timers, time and motion equipment, wrist chronographs and panelboard instruments. Includes price list. Heuer Timer Corp, 441 Lexington Ave, New York 17.

Circle 363 on Reader Service Card

HORIZONTAL-FORCE MOUNT—Bulletin 60-04.14, 2 pp. Contains photographs, dimensional drawing, specifications and applications for shock- and vibration isolater for metalworking machines and equipment with predominantly horizontal forces. Barry Controls Inc, 700 Pleasant St, Watertown 72, Mass.

Circle 364 on Reader Service Card

SERVOMECHANISMS—Bulletin 105, 2 pp. Gives construction features of 116-part servo development kit. Parts are listed by number. Precision Mechanisms Corp, 577 Newbridge Ave, East Meadow, NY.

Circle 365 on Reader Service Card

LAB ELECTROMAGNETS—Booklet, 33 pp. Lists specifications and graphically illustrates performance characteristics of 4-, 6- and 12-in. units. Magnetic-field homogeneity plots show performance obtained with numerous pole-cap configurations on electromagnets. Varian Associates, Instrument Div, 611 Hansen Way, Palo Alto, Calif.

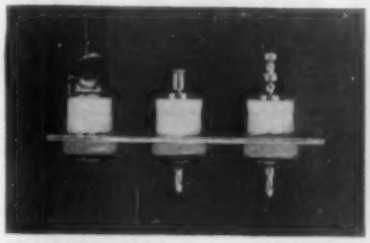
Circle 366 on Reader Service Card

FOR MORE CATALOGS AND BULLETINS

. . . 1600 of 'em—see your copy of Product Engineering's Mid-Sep 1960 Design Digest. There you will find helpful design literature, classified under 10 different headings, from important manufacturers and suppliers of components, materials, power and control systems, manufacturing processes.

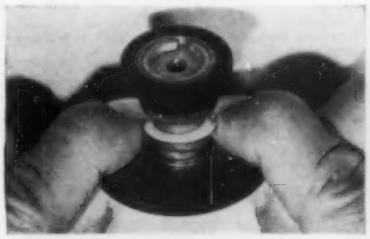
"I know you're the engineer of this outfit, but how much longer do you have to study this to get an idea . . . ?"

Design with versatile, POLYPENCO® Teflon* TFE shapes

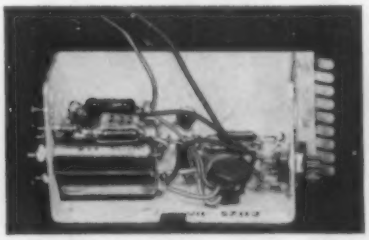


Machined from ROD
Insulators for high temperature hermetic feed-thru terminals, economically machined from POLYPENCO TFE-fluorocarbon rod. Used in transformers, capacitors, relays, etc., terminals have outstanding electrical properties and are relatively unaffected by heat or moisture.
(*Photo courtesy, Lundey Associates*)

Cut from TAPE
POLYPENCO TFE tape, operable at temperatures to 500°F., permits miniaturization of 42,000 volt transformer, reducing weight from 20 to 14 pounds. Heat resistance assists miniaturization since smaller transformers have higher temperature rises.
(*Photo courtesy, Goslin Electric & Mfg. Co.*)



Stamped from STRIP
TFE washer stamped from POLYPENCO TFE strip is spring clamped against idler wheel in record player. Low surface friction on contact permits easy turning of wheel. Resilience and non-adhesive characteristics were also important.
(*Photo courtesy, Glaser-Steers Corp.*)



Cut from TUBING
TFE spaghetti tubing in telemetering equipment maintains exceptional insulating properties at elevated temperatures, 100% relative humidity, and under constant vibration. Tubing is unaffected by soldering heats, and bending and flexing during assembly.

TEFLON SHAPES AND SIZES AVAILABLE FROM NATIONWIDE STOCK LOCATIONS

ROD
Diameter: ⅛″ to 7¼″ in various lengths

TUBING
O.D. ½″ to 12″
I.D. ¼″ to 6⅛″ depending on O.D.

SHEET
Thickness: 1/16″ to 2″
Sizes: 12″ x 12″, 24″ x 24″, and 48″ x 48″

TAPE
Thickness: .001″ to .125″
Widths: ¼″ to 24″
Ten fade-proof colors

SPAGHETTI TUBING
AWG sizes 30 to 0.
Thin and regular wall thicknesses
Ten fade-proof colors for coding

THIN WALL TUBING
I.D. ⅛″ to 1″
Wall thickness: .030″ to .050″

ROUND AND SQUARE BEADING
Round: Diam. .030″ to .150″
Square: .020″ to .156″ across the sides
Rectangular and Square Bars also available

DESIGN AND ENGINEERING HELP
Design and engineering assistance, or help on any industrial plastics problem is as near as your telephone—and yours without obligation. Take advantage of Polymer's experience and plastics know-how by calling or writing today!

**Du Pont TRADEMARK for fluorocarbon resins*

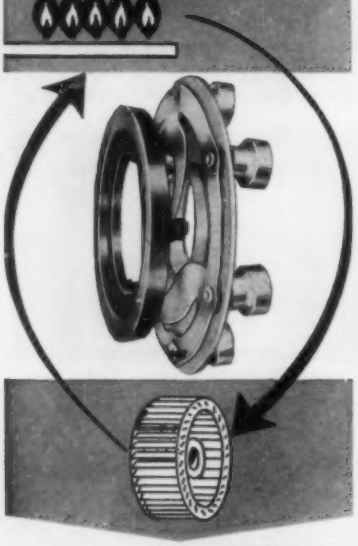
The Polymer Corporation of Pennsylvania

Reading, Pa.

POLYPENCO

INTERCONNECT FUNCTIONS

SYNPRO-TEX SPEED DETECTING GOVERNOR



A single SYNPRO-TEX speed detecting governor actuates fuel supply only after proper amount of air is furnished; then governor automatically shuts off fuel in event of blower failure for any reason.

This is just one example of how TORQ governors can inter-connect as well as control, sequence, and limit functions by detecting speeds.

TORQ governors can actuate at a single limit or a high and low limit in one or many speed ranges from zero to more than 15,000 rpm. They are designed on a patented principle which virtually eliminates operating friction, and which results in positive snap-action for a service life in excess of 1,500,000 cycles.

THE WORLD'S LARGEST MANUFACTURER OF SPEED DETECTORS

Write today for Bulletin No. 250

Patents & Patents Pending

TORQ ENGINEERED PRODUCTS, INC.
60 West Monroe Steet Bedford, Ohio
Phone: BEdford 2-4100

INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

A

Accumulators 23
Actuators
  Mechanical 103
Adhesives 86
Aluminum Coated Sheet & Strip (see Steel, Coated)
Axles 94

B

Bars
  Metal 12-13
Bearing Materials ..... 3rd Cover
Bearings
  Ball 43, 44-45, 56, 89, 113, 114
  Needle 89, 101
  Oilless ..... 3rd Cover
  Roller 43, 44-45, 50-51, 56 89, 91, 101, 105
  Sleeve ..... 3rd Cover, 97
Bellows 7, 104
Boosters 23
Brakes
  Electric 107
Brazing 111
Bushings 97, 113

C

Carbon Parts 28
Castings 53
Ceramics 119
Clutches
  Electrical 107
Coils 26-27
Connectors
  Hose 54
  Tube 54
Contactors 106
Control Panels & Switchboards 106
Controls
  Hydraulic 2
Cylinders
  Hydraulic 23, 99
  Pneumatic 23, 99

D

Drafting
  Supplies 29, 114
Drives
  Adjustable Speed 48

E

Extrusions
  Nonmetallic 117

F

Fabrics, Coated 112
Fastening Methods ..... 4th Cover, 42, 52 100, 108, 114

G

Gears 109
Governors 118

H

Handles & Knobs 112
Heating Units 32
Hydraulic Fluids 37-39

L

Liquid Level Controls 114

M

Magnets 119
Moldings
  Plastics (see Plastic Parts)
  Rubber (see Rubber Parts)
Motors, A-C
  Fractional 34-36
Motors, D-C
  Fractional 34-36
Motors, Hydraulic 2

N

Nuts 52

P

Pillow Blocks 44-45
Pins 114
Plastic Parts 90, 92-93
Plastics 47, 90
Plastics Laminated to Metal 47
Pumps
  Liquid 2, 115, 120

R

Relays 10, 33, 106, 110
Reproduction Supplies 29
Retaining Rings 115
Rings 102
Rivets 100
Rod Ends 114
Rods
  Nonmetallic 117
Rubber 82
Rubber Parts 92-93, 111

S

Screws 42, 108
Screw Thread Inserts 42
Seals 28
Sheets
  Metal 26-27
  Plastic 117
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 52
Speed Increasers & Reducers 11
Splines 103
Steel
  Alloy 5, 12-13, 46
  Coated 26-27
  Carbon 5, 12-13, 30-31, 49
  Spring 5
  Stainless 5, 12-13, 46, 49
Strip, Metallic 5

T

Thermostats 98
Tools 110
Tubes 40-41
Tubing
  Flexible Metal 54
  Plastic 117
  Seamless 40-41
  Welded 26-27

V

Valves
  Air ..... 2nd Cover, 14, 95
  Control 14
  Hydraulic 14, 95
  Solenoid ..... 2nd Cover, 110, 112

W

Washers 97
Wear Materials 84

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

Aetna Ball & Roller Bearing Co., Div., Parkersburg-Aetna Corp. 43
Allegheny Ludlum Steel Corp. 46
Anaconda Metal Hose Co. 54
Armco Steel Corp. 26-27

B/W Controller Corp. 106
Bellows-Valvair Div., International Basic Economy Corp. 14
Berry Hydraulics Div., Oliver Tyrone Corp. 115
Blaw-Knox Co. 53
Bound Brook Oil-Less Bearing Co. ..... 3rd Cover
Bower Roller Bearing Div., Federal-Mogul-Bower Bearings, Inc. 105

Carr Fastener Co., Div. of United-Carr Fastener Corp. 52

De Laval Steam Turbine Co. 120
Denison Engineering Div., American Brake Shoe Co. 2
Dir co-Gray Co. 112
Dodge Mfg. Corp. 44-45

Edgewater Steel Co. 102
Elastic Stop Nut Corp. of America 110

Fastex Div., Illinois Tool Works, 4th Cover
Federal-Mogul Div., Federal-Mogul-Bower Bearings, Inc. 97
Fenwal, Inc. 98
Fenway Machine Co., Inc. 110
Flexonics Corp., Subs., Calumet & Hecla, Inc. 7
Foote Gear Works, Inc., Brad. 109
Fulton Sylphon Div., Robertshaw-Fulton Controls Co. 104

General Electric Co., Apparatus Dept. 33-36
Great Lakes Steel Div., National Steel Corp. 30-31

Hartwell Corp. 114
Hyatt Bearings Div., General Motors Corp. 50-51

Illinois Tool Works, Fastex Div., 4th Cover
Interchemical Corp., Finishes Div. 86

Johnson Machine Co., Carlyle 107
Jones & Laughlin Steel Corp., Stainless & Strip Div. 5

Kaydon Engineering Corp. 89

Linde Co., Div. of Union Carbide Corp. 84
Link-Belt Co. 11
Lucas Milhaupt Engineering Co. 111

McGill Mfg. Co., Inc. 101
McLouth Steel Corp. 49
Marlin-Rockwell Corp. 56
Marsh Instrument Co., Div. of Colorado Oil & Gas Corp. 112
Masland Duraleather Co., The 47
Miller Fluid Power Div., Flick-Reedy Corp. 23
Minnesota Mining & Mfg. Co., Chemical Products Div. 82
Monsanto Chemical Co., Organic Chemicals Div. 37-39
Morganite, Inc. 28

National Lock Washer Co. 115
Norgren Co., C. A. 95

Parker-Kalon Div., General American Transportation Corp. 42
Pittsburgh Steel Co. 40-41
Plastic & Rubber Products Co. 92-93
Polymer Corp. of Pennsylvania 117
Post Co., Frederick 29
Potter & Brumfield, Inc., Div., American Machine & Foundry Co. 10

Republic Steel Corp. 12-13
Rockwell-Standard Corp., Transmission & Axle Co. 94
Roll & File Systems, Inc. 114
Rollway Bearing Co., Inc. 91
Ross Operating Valve Co. ..... 2nd Cover
Russell, Burdsall & Ward Bolt & Nut Co. 108

Saginaw Steering Gear Div., General Motors Corp. 103
Southwest Products Co. 114
Square D Co. 48
Steward Mfg. Co., D. M. 119

Thomson Industries, Inc. 113
Tomkins-Johnson Co. 99
Torq Engineered Products, Inc. 118
Townsend Co., Cherry Rivet Div. 100

Valcor Engineering Corp. 110
Vulcan Electric Co. 32
Vulcan Rubber Products Div., Reeves Bros., Inc. 112

Warrick Co., Charles F. 114
Western Rubber Co. 111
Westinghouse Electric Corp. 18-19
White Dental Mfg. Co., S.S., Plastics Div. 90

LLOYD R. LAWRENCE *advertising sales manager*
P. F. PRITCHARD *manager, market development*
THOMAS R. COASH *circulation*
RUSSELL T DOUGLAS *business manager*

ADVERTISING SALES STAFF

ATLANTA 9 . . . Ray K. Burnet, 1375 Peachtree St., N.E., Trinity 5-0523
BOSTON 16 . . . M. A. Williamson, Jr., McGraw-Hill Bldg., Copley Square, Congress 2-1160
CHICAGO 11 . . . Mid-Western Adv Sales Manager, A. E. Meanor; R. W. Bruley, L. Anderson, 520 N Michigan Ave, Mohawk 4-5800
CLEVELAND 13 . . . A. F. Tischer, 1164 Illuminating Bldg, 55 Public Sq, Superior 1-7000
DALLAS 1 . . . John Grant, 901 Vaughn Bldg, 1712 Commerce St, Riverside 7-5117
DENVER 2 . . . John W. Patten, Tower Bldg, 1700 Broadway, Alpine 5-2981
DETROIT 26 . . . P. B. Robinson, 856 Penobscot Bldg, Woodward 2-1793
HOUSTON 25 . . . Gene Holland, W-724 Prudential Bldg, Jackson 6-1281
LOS ANGELES 17 . . . Robert Obenour, 1125 West 6th St, Huntley 2-5450
NEW YORK 36 . . . B. K. Adams, F. J. McKinley, 500 Fifth Ave, Oxford 5-5959
PHILADELPHIA 3 . . . John B. Lewis, H. M. Nicholson, 6 Penn Center Plaza, Locust 8-4330
PITTSBURGH 22 . . . C. F. Leveroni, 4 Gateway Center, Express 1-1314
PORTLAND 4, ORE. . . . Scott Hubbard, 445 Pacific Bldg, Capitol 3-5118
ST LOUIS 8 . . . R. W. Bruley, 3615 Olive St, Continental Bldg, Jefferson 5-4867
SAN FRANCISCO 4 . . . W. C. Woolston, 68 Post St, Douglas 2-4600.

SUBSCRIPTIONS. Send subscription correspondence and change of address to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St, New York 36, NY. Subscribers should notify Fulfillment Manager promptly of any change of address including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change of address to become effective. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connections must be indicated on subscription orders.

OFFICERS OF THE PUBLICATION DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.
EMPLOYMENT OPPORTUNITIES 116

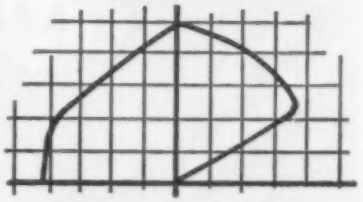
Newest Addition to

STEWARD'S MAGNET FAMILY

High Energy Product

F-500

ORIENTED CERAMIC PERMANENT MAGNET



BH=3.5 x 10^6 G.Oe
Hc=2000 Oe Br=3900 G

APPLICATIONS:

LOUDSPEAKER MAGNETS MAGNETIC SEPARATORS AND OTHERS REQUIRING HIGH BH PRODUCT AND COERCIVITY

Look to D. M. Steward Manufacturing Company for all of your Ceramic Magnet requirements.

Write for F-500 brochure to:

D. M. STEWARD MFG. CO.
3640 JERROME AVENUE
CHATTANOOGA, TENNESSEE

Here's data
on the ideal pump for
design applications

Announcing NEW DE LAVAL IMO Pump Bulletin

New Bulletin 3200 contains all the data you need on De Laval IMO constant-displacement, rotary, screw type pumps. In its pages you will find (1) extensive application data including charts on fuel oil, SAE oil, and turbine oil viscosities; (2) selection information, including specific examples; (3) complete performance data on each IMO model as well as (4) dimension drawings and tables. Write today for your copy of this valuable, 40-page bulletin on the unique IMO pump.

DE LAVAL STEAM TURBINE COMPANY
801 NOTTINGHAM WAY, TRENTON 2, N. J.

DL-2308

PERSONAL READER SERVICE

USE ATTACHED CARDS FOR PERSONAL COPIES OF ADDITIONAL PRODUCT DESIGN DATA

. . . Data on Materials and Components
. . . Free Article Reprints
. . . New Catalogs and Bulletins
. . . Brochures on Advertised Products
. . . Personal Suscriptions to PRODUCT ENGINEERING

Valuable new data on product design engineering — readily available to you — FREE.

Just circle the numbers on the request cards that are identical with the numbers printed under each Advertisement, New Product and Bulletin throughout this issue.

Reprint numbers are prefaced with the letter "P". *One free reprint* is available for each article offered.

USE THIS CARD

to be sure to get your personal subscription to PRODUCT ENGINEERING sent each week to your home or office.

Now only $3 per year (U.S.A.)

Issue of December 12, 1960
PRODUCT ENGINEERING
Card expires February 13, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Issue of December 12, 1960
PRODUCT ENGINEERING

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

ADD TO YOUR DESIGN REFERENCE FILE FROM

EDITORIAL REPRINTS AVAILABLE

(Single reprints free, additional copies 6 for $1)

P50—WEAR OF ROLLING SURFACES
New equations give life expectancy for gears, cams, bearings.

P51—PNEUMATICS SIMULATES ELECTRONICS
Dimensional analysis of all units needed in control service.

P52—SELECTING SOLENOIDS
A guide to ac or dc, and linear or rotary types.

P53—LIGHT-DUTY BELT DRIVES
Performance compared for all five basic types.

P54—EPICYCLIC GEAR SYSTEMS
Modified equations give volume, power capacity, ratios, and stresses.

P56—TAPERED CANTILEVER BEAMS
How to calculate stresses and deflections for five sections.

P58—STRONG ALUMINUM ALLOYS
How the new X2020 stacks up with other high-strength alloys.

P59—THE RESPONSE EQUATION
Some graphical tricks that eliminate tedious slide rule work.

P60—ACCELEROMETER
Evaluation of all types suitable for control applications.

P61—DIMENSIONAL STABILITY IN PRECISE PARTS
How properties change under stress and heat.

P62—FRICTION COEFFICIENTS
Complete table; how to adapt values to actual service.

P64—BENDING GAGE
New strain gage system measures from one side of section.

P65—HELICAL GEARS
How to change pitch diameter by varying pitch angle.

P66—SLIDERULES
Get more from your sliderule shortcuts to solution of complex problems to greater accuracy.

P67—NEW DRAWING SYSTEM
Permits direct projection between any two orthographic views.

P68—COPPER CASTING ALLOYS
Properties of 12 high-conductivity alloys charted for precise selection.

P69—FLUID FILTERS
Comprehensive report evaluates all types of filtering method and materials for hydraulic and pneumatic systems.

P70—BOLTING TORQUE FOR PLATED BOLTS
Effect of plating on bolt, nut or washer on bolt tension.

P71—STAINLESS HONEYCOMB PANELS
Basics of design, materials to use, practical details of construction.

P72—SAMPLING THEORY
How representative is that sample? Here's the mathematical proof.

(please print or type) *If this is change of address, check box* ☐

Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P50 P51 P52 P53 P54 P56 P58 P59 P60 P61
P62 P64 P65 P66 P67 P68 P69 P70 P71 P72

*MULTIPLE PRODUCT ADS

Key No.	Specific Product

FRESH NEW DESIGN IDEAS EVERY WEEK!

Have your own personal subscription to PRODUCT ENGINEERING sent each week to your office or home. ACT NOW. Fill out this card today to make sure you won't miss a single issue.

☐ 1 year—NOW $3 U.S. only* ☐ 2 years—NOW $4

*Canada
1 year—$5
2 years—$8

☐ Payment enclosed
☐ Bill me

Name ..... Title .....

Home ☐ .....

Address Office ☐ ..... Dept.....

City ..... Zone ..... State .....

Company Name ..... Product Mfgd .....

NEW CATALOGS AND BULLETINS

GENERAL ENGINEERING

363—Stopwatch Guide, 16 pp, Heuer Timer Corp.

RESEARCH AND TEST EQUIPMENT

366—Lab Electromagnets, 33 pp, Varian Associates, Instrument Div.

METALS AND ALLOYS

355—Alloy Steel Castings, 4 pp, Alloy Steel & Metals Co.

356—Titanium Tubing, 3 pp, Superior Tube Co.

359—Titanium Alloy, 11 pp, Titanium Metals Corp of America

NON-METALLIC MATERIALS, FINSHES

350—Man-Made Fibers, 71 pp, American Viscose Corp.

360—Diallyl Phthaltes Resin Molding, 27 pp, Food Machinery & Chemical Corp.

POWER TRANSMISSION

352—Miniature Clutches and Brakes, 4 pp, Technology Instrument Corp.

THIS WEALTH OF VITAL INFORMATION . . .

NEW COMPONENTS

RESEARCH AND TEST EQUIPMENT

331—Ring Dynamometer Transducer
332—Tiny Strain Gage Transducer

POWER TRANSMISSION

303—Stationary Magnet Clutch
304—Self-lubricating Flexible Coupling
308—Compact Air Clutch
322—Miniature Ball Joint
323—Flexible Drive Shafts
326—Single-end Magnetic Clutch

MECHANICAL PARTS

322—Miniature Ball Joint

FASTENING AND JOINING

307—Self-locking Screw Insert
310—Heavy-duty Bond Clamp
316—Silicone Rubber Cement

MOTORS, ENGINES AND CONTROLS

300—Non-contact Sensing Heads Reduce
301—Punched Card Switching System
302—Setable Interval Timer
319—Lightweight Pressure Transducer
321—High-temperature Transducers
325—Fan and Blower Motors
328—Control Knob Lock
329—Radial Air-gap Motor
330—Servo Assembly

ELECTRICAL, ELECTRONIC COMPONENTS

300—Non-Contact Sensing Heads Reduce
301—Punched Card Switching System
302—Setable Interval Timer
305—Hermetically-sealed Relays
306—Miniature Indicator Light
309—Rotating Cam Limit Switch
314—Metal-cased Limit Switches
319—Lightweight Pressure Transducer
320—General Purpose Relay
321—High-temperature Transducers
324—Miniature Circuit Breaker
328—Control Knob Lock

HYDRAULIC, PNEUMATIC EQUIPMENT

310—Heavy-duty Band Clamp
311—Balanced Spool Solenoid Valve
312—Disposable Filter Cartridge
313—Interchangeable Air Cylinders
315—Self-sealing Disconnect
317—Pressure-balanced Gear Pumps
318—Miniature Air Line Assembly
327—O-seal Cartridge Inserts

MECHANICAL PARTS

358—Plastic Lenses, 4 pp, Fostoria Corp, Applied Products Div.

364—Horizontal-force Mount, 2 pp, Barry Controls Inc.

MOTORS, ENGINES AND CONTROLS

362—Squirrel Cage Induction Motors, 8 pp, Lincoln Electric Co.

365—Servomechanisms, 2 pp, Precision Mechanisms Corp.

ELECTRICAL, ELECTRONIC COMPONENTS

353—Acceleration Switches, 2 pp, W L Maxon Corp., Instruments Div.

357—Multiple Connectors, 6 pp, Amp Inc.

361—Digital Timers, Counters, 2 pp, Chrono-Log Corp.

365—Servomechanisms, 2 pp, Precision Mechanisms Corp.

HYDRAULIC, PNEUMATIC EQUIPMENT

351—Hydraulic Rotary Actuators, 16 pp, Houdaille Industries Inc.

354—Hydraulic and Circulating System Oils, 1 pp, Sun Oil Co.

(please print or type) *If this is change of address, check box* ☐

Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P50 P51 P52 P53 P54 P56 P58 P59 P60 P61
P62 P64 P65 P66 P67 P68 P69 P70 P71 P72

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product

(please print or type) *If this is change of address, check box* ☐

Name ..... Title .....

Street .....

City ..... Zone ..... State .....

Company ..... Major Product Manufactured .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P50 P51 P52 P53 P54 P56 P58 P59 P60 P61

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product

USE THESE PREPAID CARDS FOR

- More information on advertised products
- More data on new materials and components
- Copies of catalogs and bulletins offered
- Free editorial reprints
- Your personal subscription to PRODUCT ENGINEERING

Issue of December 12, 1960
PRODUCT ENGINEERING
Card expires February 13, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Issue of December 12, 1960
PRODUCT ENGINEERING
Card expires February 13, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

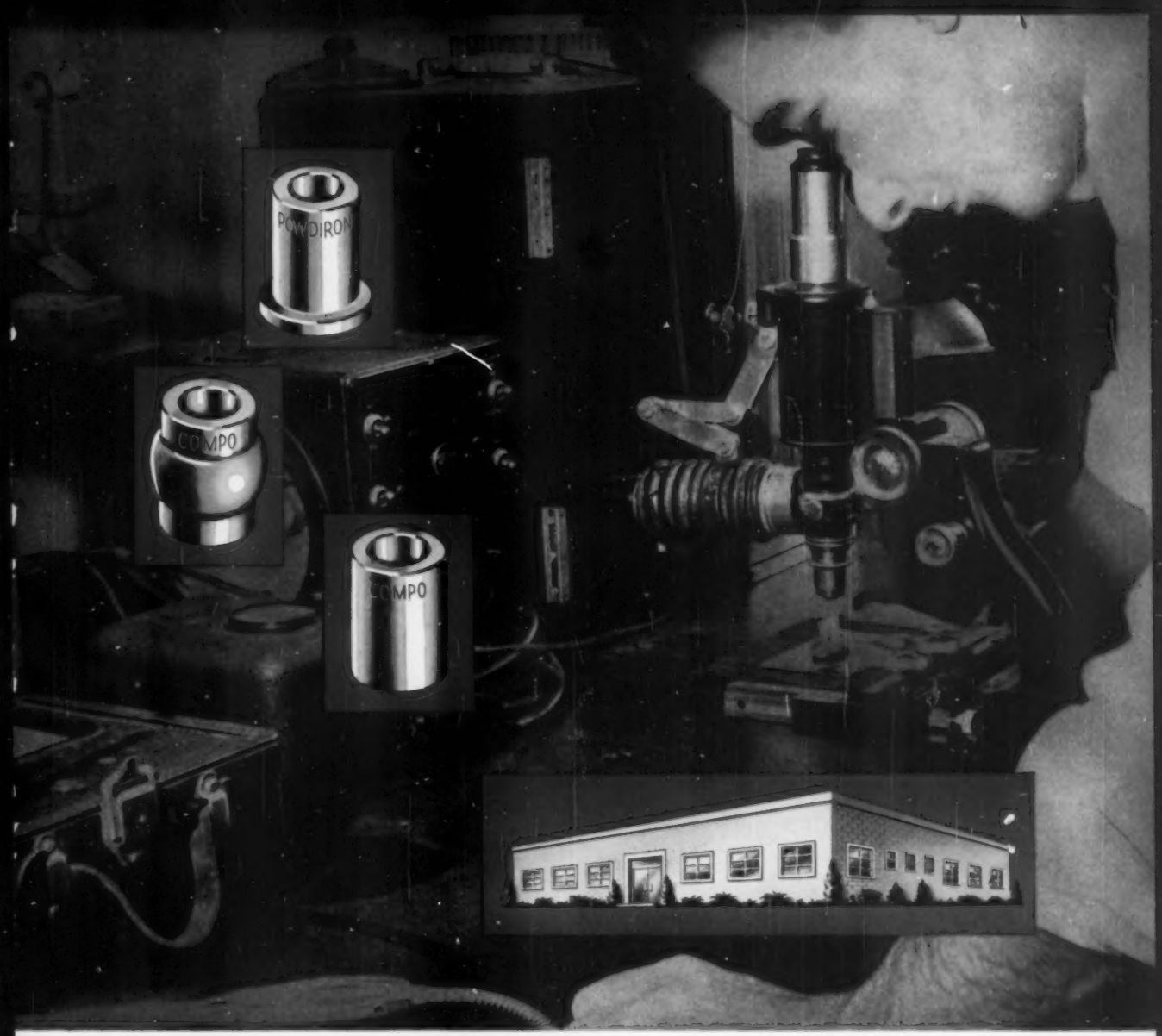
PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Information Sent Promptly

An Opportunity To Get More Information Quickly, Conveniently

Circle 202 Reader Service Card



Better bearings begin here in the newly constructed laboratories of Bound Brook's Research and Development Division. Here, with new facilities and modern equipment, Bound Brook's highly specialized talents create new bearing materials, help you develop new product applications. Here, Bound Brook engineers employ unique test equipment to duplicate any conditions, service-test your bearings before they're put in production. If you want to turn your problems into new ideas, new designs, new bearing applications . . . turn to Bound Brook!

BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
Pioneer in Powder Metallurgy Bearings and Parts.
Plants at Bound Brook, N.J. and Sturgis, Mich.

Tough fastening problem...simple answer:

FASTEX® PLASTI-GROMMETS®

Using Fastex Plasti-Grommets to mount license plates demonstrates their use in blind applications, just one of their unique solutions to fastening problems. They are also ideal for any application requiring rugged fastening strength, electrical or thermal insulation, corrosion-resistance and ease of assembly. They snap into place easily and lock tight when the screw is driven.

Fastex Plasti-Grommets have been specified by leading manufacturers for years. Typical of the many mass-production industries they serve are television, where they are used as electrical insulation fasteners, and in manufacturing refrigerators where they serve as thermal insulation spacers.

SEND FOR NEW CATALOG FEATURING STANDARD PLASTI-GROMMETS!

Fastex Standard Plasti-Grommets can mean big cost-savings! This new catalog contains handy ordering information and idea-suggesting case studies. See where Plasti-Grommets can cut your costs!

CIRCLE 203 ON READER SERVICE CARD

FASTEX

A DIVISION OF ILLINOIS TOOL WORKS
195 Algonquin Road, Des Plaines, Illinois
In Canada: SHAKEPROOF/FASTEX
Division of Canada Illinois Tools Ltd., Don Mills, Ontario

iTW